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DEVELOPMENT AND APPLICATION OF A MODEL OF FALLOUT SHELTER STAY --ETC(U)

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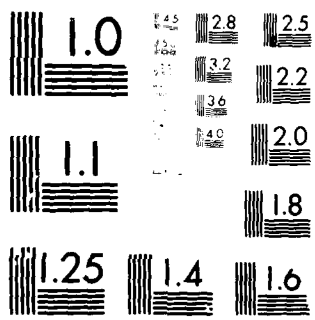

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DEVELOPMENT AND APPLICATION OF A MODEL OF FALLOUT SHELTER STAY TIMES

The BDM Corporation
7915 Jones Branch Drive
McLean, Virginia 22102

29 December 1978

Final Report for Period 15 June 1978—29 December 1978

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The Attrition Rate Model is a model of how and at what rate individuals leave fallout shelters. This document is a description of the model and the methodology used to develop it. In addition, this document serves as a user's guide to the application of the model. Two complete examples are presented--a pencil-and-paper study of fallout casualties in a representative Soviet city, and an application to a red-on-blue SIDAC scenario. The complete programs necessary to run the SIDAC post-processor are also included.

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EXECUTIVE SUMMARY

THE PROBLEM

During the exercise of strategic simulations and models for the estimation of the total number of injuries and fatalities following a nuclear exchange, a number of critical parameters must be employed whose exact values are unknown, yet whose impact on simulated results is considerable. One such parameter is the assumed fallout shelter 'stay time' of the civilian population.

One standard currently employed in the strategic simulation community is the set of effective protection factors developed by SRI (4), based on the following stay time assumptions:

(1) 7 days fully sheltered followed by 14 days partially sheltered for shelters exhibiting adequate plumbing/water facilities, and

(2) 2 days fully sheltered followed by 3 days of partial sheltering for facilities exhibiting generally inadequate plumbing/water facilities.

These protection factors are incorporated, for example, by the Studies, Analysis, and Gaming Agency (SAGA) in the Single Integrated Damage Assessment Capability (SIDAC) for the estimation of fallout fatalities and injuries in various strategic scenarios. However, the shelter stay times reflected in these parameters represent little more than best reasonable estimates of shelter stay. The use of these and other 'reasonable' assumptions of stay generate a wide variation in the number of simulated fallout casualties.

As a result, a definite need exists for the development of a methodology to justify choice of stay time assumption and to reduce the variability associated with the human factor in large scale simulations.

OBJECTIVE

The objective of this study is threefold:

(1) First, to develop a model of fallout shelter stay time based on the application of principles of human behavior to an empirical database;

(2) Second, to provide a guide for, and examples of, the use of this model for the strategic analyst specifically involved in the simulation of fallout casualties in strategic exchanges; and

(3) Third, to reduce the wide variation in simulated strategic casualties currently displayed as a result of the spectrum of stay times employed.

APPROACH--DEVELOPMENT OF THE MODEL

The model of fallout shelter stay developed in this study, denoted the Attrition Rate Model, is based on a statistical analysis of a quantitative database of human response in disaster situations. Behavioral studies of human response to disasters were systematically surveyed for quantative estimates of time spent in shelters and qualitative data bearing on the behavioral profile of shelterees. Three thousand estimates were derived from approximately seven hundred studies. Eight general categories of data were identified:

(1) physiological,
(2) shelter space,
(3) shelter type,
(4) warning,
(5) training,
(6) shelter management,
(7) evacuation posture, and
(8) communication.

For each of these categories, estimates of percent shelteree attrition were derived as a function of time since sheltering. Results were refined by eliminating data from incidents not analogous to a post-attack environment. Qualitative behavior profiles derived from questionnaires, interviews and observations were developed and used to interpret the quantitative data.

The resulting model expresses, for a variety of shelter environments, the percent of shelterees leaving the shelter as a function of time since sheltering. It was found that, in contrast with traditional assumptions which assume entire population either completely in or out of

shelters at any given time, that the expected behavior response of a sheltered population is one of constant 'attrition' from the shelter.

UTILITY--A GUIDE TO THE MODEL'S USE

The utility of the Attrition Rate Model of fallout shelter stay is based on two features of the model:

(1) First, that it provides a justification for choice of stay time assumption in strategic simulations by virtue of its basis in a quantitative database, and

(2) Second, that it provides the potential for the reduction in the wide variation of simulated fallout casualties associated with the range of stay time assumptions traditionally employed.

In order to allow the strategic analyst to incorporate these advantages into current estimates of fallout casualties, and to derive full advantage from the Attrition Rate Model in strategic simulations, a guide to the use of the model in both pencil-and-paper and large scale simulations is developed and presented. The guide focuses on both the generic step-by-step procedure for the estimation of fallout casualties, and is illustrated by two explicit applications: a study of casualties in Tbilisi, Soviet Georgia, and an investigation of casualties associated with a SIDAC scenario.

PREFACE

This report is submitted to the Defense Nuclear Agency by the BDM Corporation under Contract Number DNA-001-78-C-0060 and represents work conducted during the period 1 June 1978 through 1 January 1979.

The objective of this study is to develop a model of fallout shelter stay times and to provide a guide for its application in strategic simulations. The model, denoted the Attrition Rate Model, is based on an empirical database constructed from a systematic review of behavioral response in American disasters. Traditionally, stay time assumptions employed in strategic simulations have been based on little or no quantitative data, but have represented only reasonable or computationally convenient assumptions. The use of an empirical database in the Attrition Rate Model provides a justification for the choice of simulation stay time, and thus contributes to reducing the wide variation in simulation results characteristically associated with the 'human element'.

The utility of the Attrition Rate Model can be measured only by its usefulness and applicability within the strategic simulation community. For this reason, the material in this report is presented in a concise manner, specifically focused toward providing the strategic analyst with a guide for its use in simple 'pencil and paper' studies and large scale simulations, such as the Single Integrated Damage Assessment Capability (SIDAC).

The principal authors of this report are J. H. Kinrich, N. J. Maresea, and R. A. Levit.

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SECTION 1
INTRODUCTION TO THE PROBLEM

1.1 BACKGROUND

One key element involved in the overall determination of the effectiveness of U.S. and Soviet strategic nuclear forces is the use of strategic exchange simulations and targeting models. Among these simulations are the Single Integrated Damage Analysis Capability (SIDAC), which is a large scale nuclear exchange computer simulation, and CIVIC, COBRA, READY, and RISK II (1, 8). These tools allow strategists to investigate different scenarios characterized by variations in the distribution, type, yield, and accuracy of strategic weapons; alternate mission types (counterforce, counter-value, etc.); differing target vulnerabilities; and other strategic issues. The resulting number of fatalities and injuries sustained by the population through simulated prompt, collateral, and fallout effects contributes directly to estimates of a country's ability to recover; a process of significant strategic importance to any nation. However, during the exercise of these simulation tools for the determination of population attrition, a number of critical parameters must be employed whose exact values are unknown, yet whose impact on simulation results is considerable. One such parameter is the length of time the civilian population can be expected to remain in fallout shelters following a nuclear attack.

Currently, the Defense Nuclear Agency and others employ fallout protection factors developed by SRI (4). These standard PFs are heavily dependent on the shelter stay time assumptions used to generate them. SRI uses two sheltering assumptions in its study; these have been called the "Seven Day" and "Two Day" assumptions. For example, developed countries are assumed to have shelters with sufficient food, water, and plumbing facilities to allow a seven day stay in the shelter. This seven day period is followed by fourteen days of partial shelter occupancy: 2/3 of the day in the shelter, and 1/3 of the day outside. Lesser developed countries do

not have as highly developed water and plumbing systems. Therefore, shelters in these countries are assumed to allow two days of complete sheltering, followed by three days of partial (2/3 in, 1/3 out) sheltering.

In order to provide information on the extremes of shelter stay, some modelers also investigate two additional possibilities: Indefinite sheltering (100% sheltering until radiation level reaches zero) and no sheltering.

These variations in currently employed stay time assumptions support a wide variation in resulting population fatalities, yet each assumption represents little more than a "reasonable" estimate or computational simplification of shelter stay. To date the user has no empirical basis by which to choose a fallout shelter stay time. A definite need exists for the development of a methodology to justify the choice of stay time assumptions and to reduce the variability associated with the human factor in large scale simulations.

Determination of fallout shelter stay time involves the evaluation of human behavior under stressful situations. As such, a behavioral science approach to stay time estimation will provide the needed human factors element. This study represents an initial effort to address these needs in a quantitative manner.

1.2 STUDY OBJECTIVE

The objective of this study is threefold:

(1) First, to develop a model of fallout shelter stay times based on the applications principles of human behavior to an empirical database

(2) Second, to provide a guide for the use of this model as a tool in casualty investigation, and;

(3) Third, to reduce the wide variation in simulated strategic casualties currently displayed as a result of the spectrum of stay time assumptions employed.

In support of these objectives, a model of fallout shelter stay times, denoted the Attrition Rate Model, is constructed based on a compliation and anlaysis of quantitative stay time estimates from behavioral studies of disasters.

This document is a guide to the modeling methodology and applications of the model itself. Instruction in the use of the model in both "pencil-and-paper" and large scale computer simulation studies is provided with an example application for each type of study. These examples illustrate the reduction in the variability of fallout casualties, while the model itself provides a justification for the choice of stay time assumptions.

1.3 REPORT ORGANIZATION

The remainder of this report is composed of three sections. In Section 2, the methodology employed in the development of the Attrition Rate Model is presented along with a discussion of model extensions and limitations. A guide for the use of the model as a tool in casualty investigation and examples of its use are given in Section 3. These examples comprise first; an exemplary pencil-and-paper study of casualties associated with a simulated laydown on the city of Tbilisi, Soviet Georgia, and second; a computer simulated investigation of casualties based on a SIDAC red-on-blue simulation. Finally, Chapter IV discusses additional applications and extensions of the model.

SECTION 2
A MODEL OF FALLOUT SHELTER STAY TIMES

2.1 INTRODUCTION

In order to develop a quantitative model of fallout shelter stay times in a nuclear environment, an empirical database must be developed which reflects as closely as possible the expected circumstances following a nuclear exchange. From the perspective of the sheltered population, this environment is characterized by the shelter atmosphere and the existence and/or perception of a real external threat.

The only peacetime experience available which provides quantitative data on shelter stay times in real threat environments is that of disaster studies. Indeed, a fundamental assumption of the present study is that a post-attack environment _is_ a disaster, and that human response to a nuclear disaster is an extropolation of human response to natural disasters. Consequently, the model of fallout shelter stay time proposed in this study represents a quantitative summary of stay times based on an extensive disaster database characteristic of the American population. Because this database is derived from a spectrum of disaster shelter types, and includes behavioral response to real threats, it is felt to closely reflect the key behavioral determinants expected in a post-attack nuclear environment.

The development of this model, denoted the Attrition Rate Model, by the use of a quantitative empirical database provides a justification for its use as the "stay time assumption" in strategic simulations. Currently employed stay time assumptions are based on little or no data, but represent at best only reasonable approximations, and at worst, computationally convenient parameters. As such, there is no specific criteria by which to choose among assumptions, yet simulation results are quite sensitive to the assumptions employed. Thus, the Attrition Rate Model provides

a distinct advantage to the strategic analyst by providing a more justifiable choice of stay time, and consequently a reduction in the variation in simulation results traditionally associated with the 'human element'.

2.2 OVERVIEW OF MODEL DEVELOPMENT

The approach employed in developing the Attrition Rate Model of fallout shelter stay times involved the construction of a quantitative database of stay time estimates extracted from relevant behavioral studies, and an analysis of the data for application to a post-attack environment. The resulting 'model' is cast in the form of graphical displays (with associated analytical representations) illustrating the percent of the sheltered population expected to exit the fallout shelters as a function of time during the first ten days following shelter entrance.

Approximately seven hundred studies of human response to disaster, isolation and confinement, and shelter occupancy were reviewed, from which about three thousand estimates of stay time were extracted. These data were reduced to five hundred and seventy six points by eliminating of data from incidents not analogous to a post-attack environment. Within this final database, a frequency analysis was performed to identify general catagories of data which characterized reported motivations of shelter exit. These included physiological, shelter type, shelter space, warning, training, shelter management, evacuation posture, and communication. Data characteristic of each of these parameters were least-squares-fitted to linear, and in some cases simple power law, response curves. Qualitative behavior profiles derived from questionnaries, interviews, and observations were also developed, and used to interpret these quantitative data. Figure 2-1 illustrates the overall approach employed.

By combining data representing stay time estimates reflecting the best configurations of each of the above categories and data representing worst configurations, 'best case' and 'worst case' extremes in expected shelter exit response were developed. In this form, the model represents a useful tool for the investigation of the expected variation in fallout casualties due to the range of expected human response.

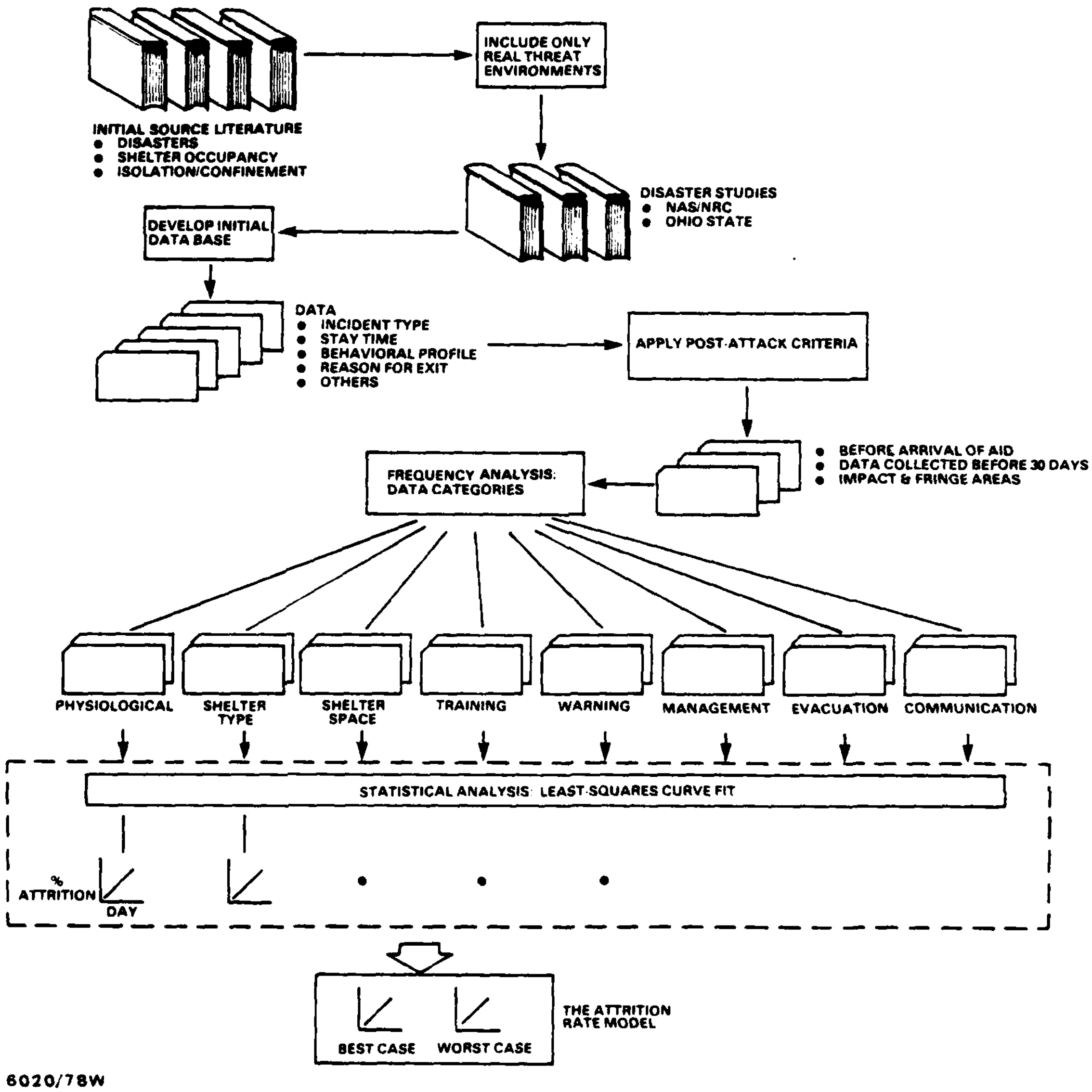

Figure 2-1. Development of the attrition rate model of fallout shelter stay times.

2.3 DEVELOPMENT OF THE MODEL

2.3.1 The Database

The source literature reviewed for the development of the Attrition Rate Model included approximately seven hundred studies of disaster, isolation and confinement, and fallout shelter occupancy. The overwhelming majority of the quantitative data subsequently employed in the model database was based on disaster studies of the National Academy of Sciences--National Research Council (Disaster Research Group), the National Opinion Research Council, and the Ohio State Disaster Research Team (2,9,10,11). Table 2-1 depicts the nature of the disaster research reports included in the study. A decision was made not to include results of fallout shelter occupancy and isolation/confinement studies since the component of behavior reflecting the presence of a real external threat, as would be characteristic of a nuclear environment, was absent from these studies.

From the disaster studies, quantitative estimates of shelter stay times were identified and added to the database. For this purpose, the act of 'sheltering' was considered to be any overt behavior whose objective was to partially or completely protect the individual from the physical effects of an incident. Thus, in the case of a flood, for example, the 'shelter' may have been a rooftop, or in the case of an earthquake, under a table in the basement. Actual stay time data represent first hand reports via questionnaires and interviews with study participants or disaster victims, as well as observations reported by reliable observers such as the Red Cross, police, fire rescue, and other personnel involved in disaster recovery.

Stay data extracted from these studies were recorded by including event type and description, shelter type, stay time, reason for leaving, and time of arrival of aid. All data were coded and placed on computer cards for subsequent processing. As a check on internal consistency, the source documentation was divided in two, and data were extracted from each half by different analysts. The resulting response curves based on these two sets of data were found to correlate closely.

Table 2-1. Sources of disaster studies.

BEHAVIORAL ASPECTS OF FALLOUT SHELTER STAY

SOURCES DISASTER RESEARCH

DISASTER AGENTS	EVENTS STUDIED	FIELD STUDIES	INTERVIEWS AND QUESTIONNAIRES	REPORTS
AIRPLANES	4	3	176	7
BLIZZARDS	3	2	19	2
EARTHQUAKES, ETC.	8	8	1,831	10
EPIDEMICS AND EPIDEMIC THREATS	5	5	2,487	7
EXPLOSIONS AND FIRES	13	13	678	11
FALSE ALERTS	6	7	2,953	7
FLOODS	12	16	3,319	27
HURRICANES AND TYPHOONS	12	9	364	9
MINE DISASTERS	2	3	297	5
TORNADOES	20	31	2,092	34
TOXICOLOGICAL SUBSTANCES	8	8	227	6
WORLD WAR II BOMBINGS	4	6	7,163	4
MISCELLANEOUS	6	3	18	4
TOTALS	103	114	21,624	121

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The initial three thousand point database developed in this manner represented a summary of quantitative stay time estimates and event characteristics from reliable observers, and provided a foundation for the development of the Attrition Rate Model.

2.3.2 Data Analysis

In order to obtain a database most representative of a post-attack environment, a number of criteria were imposed by which to eliminate inappropriate data from the initial database. These criteria demanded that the data represent:

(1) incidents characterized by brief, intense expenditure of energy;

(2) stay time estimates <u>before</u> the arrival of aid;

(3) data collected within 30 days of the incident; and,

(4) data collected within impact and fringe areas.

The application of these criteria reduced the database from three thousand to approximately six hundred data points.

Within this final database, a frequency analysis was employed to identify categories of data associated with shelter exit. Eight such categories were identified:

1) physiological, 2) shelter space, 3) shelter type, 4) warning, 5) training, 6) shelter management, 7) evacuation posture, and 8) communication. The data were partitioned among these categories, and a least-squares linear fit was performed to develop response curves for each category. The resulting curves are shown in Figure 2-2. Note that in some cases, it was possible to fit the data to a simple power law more accurately than to a straight line.

For the purpose of employing these results in the investigation of fallout casualties, two additional cases were developed: Best Case, and Worst Case. For the Best Case response, all data representative of the best cases of each of the above eight categories were included. These data were then fit to a straight line, as shown in Figure 2-3a. Thus, this result summarizes the expected responses reflecting adequate food, water

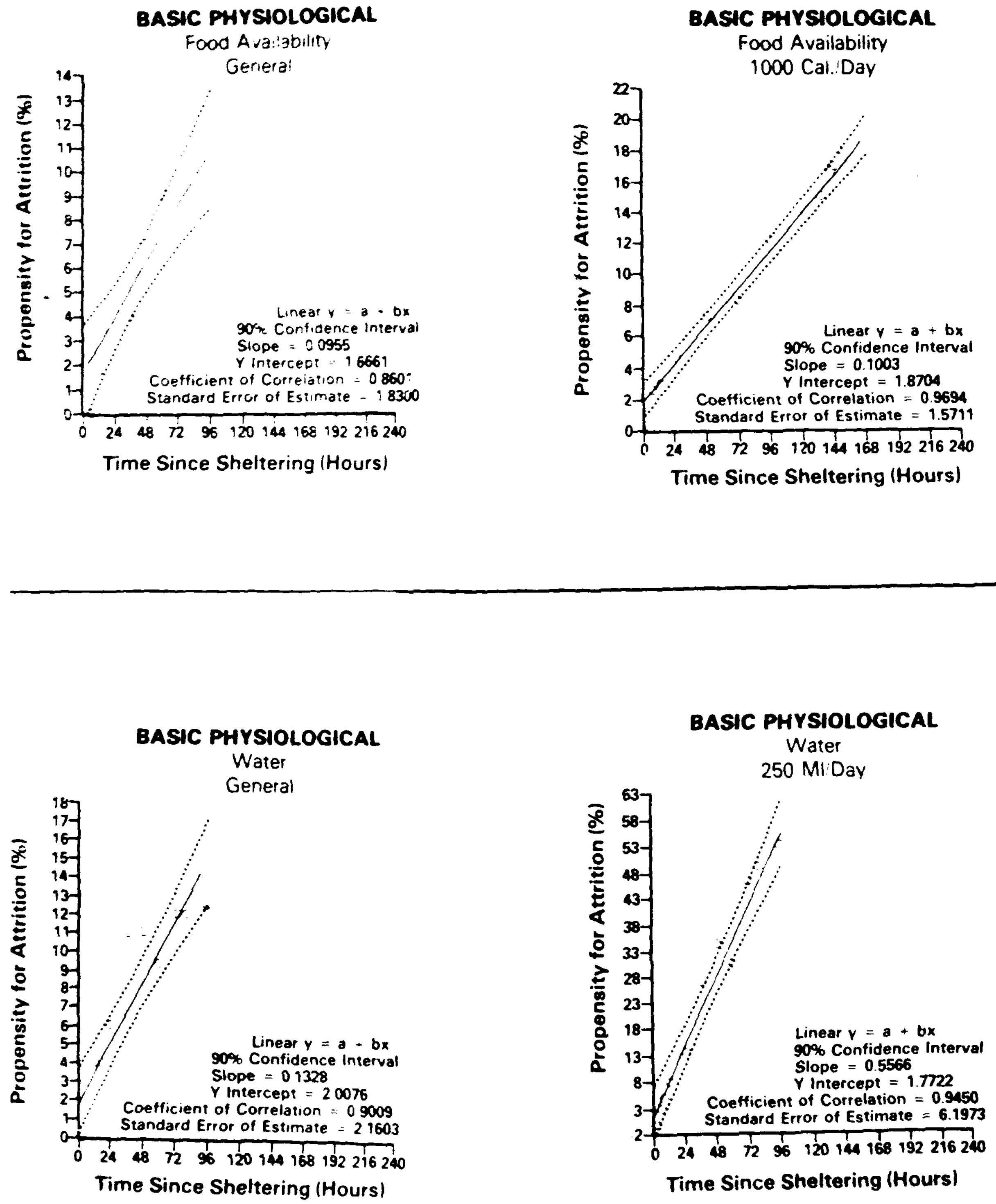
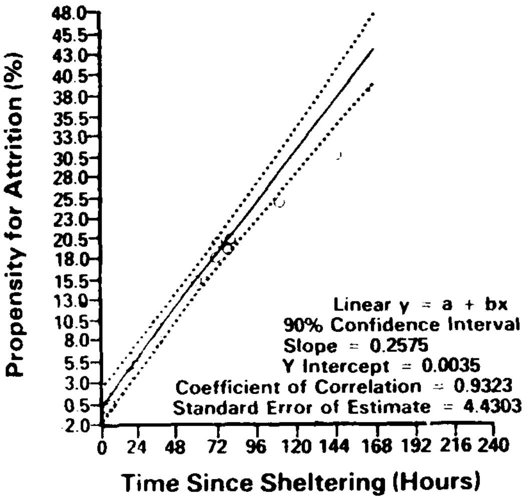
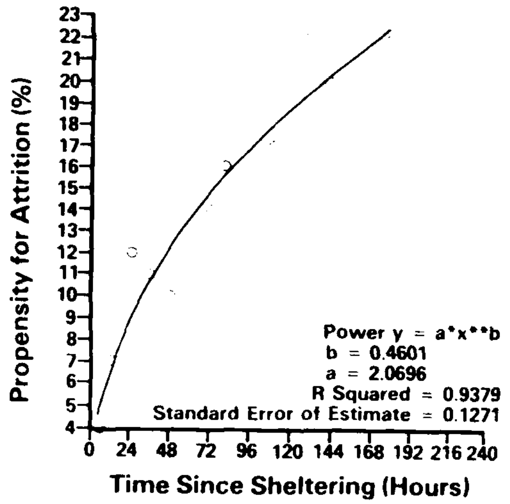


Figure 2-2. Graphs of the general attrition rate equations.

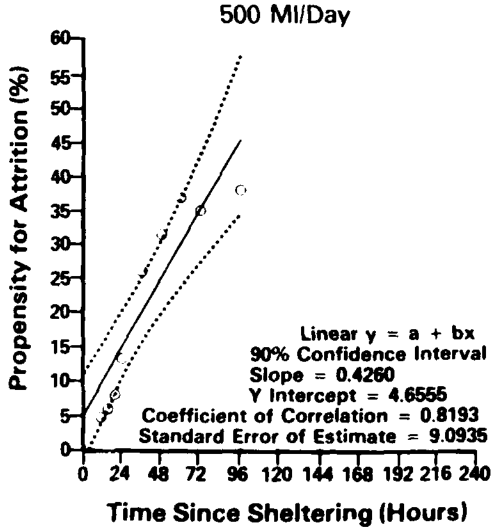
BASIC PHYSIOLOGICAL
Food Availability
No Food Available



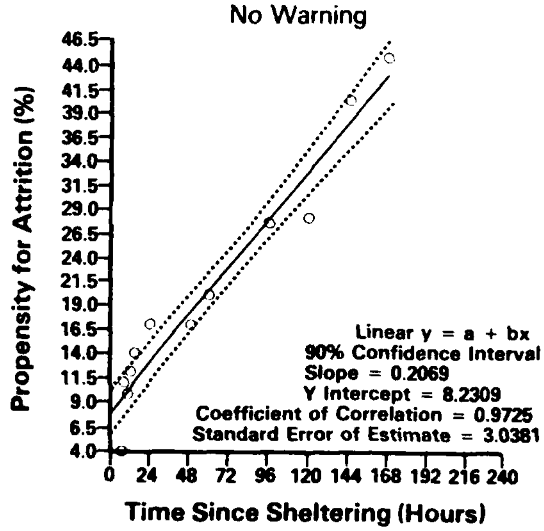
WARNING
Warning



BASIC PHYSIOLOGICAL
Water
500 Ml/Day



WARNING
No Warning



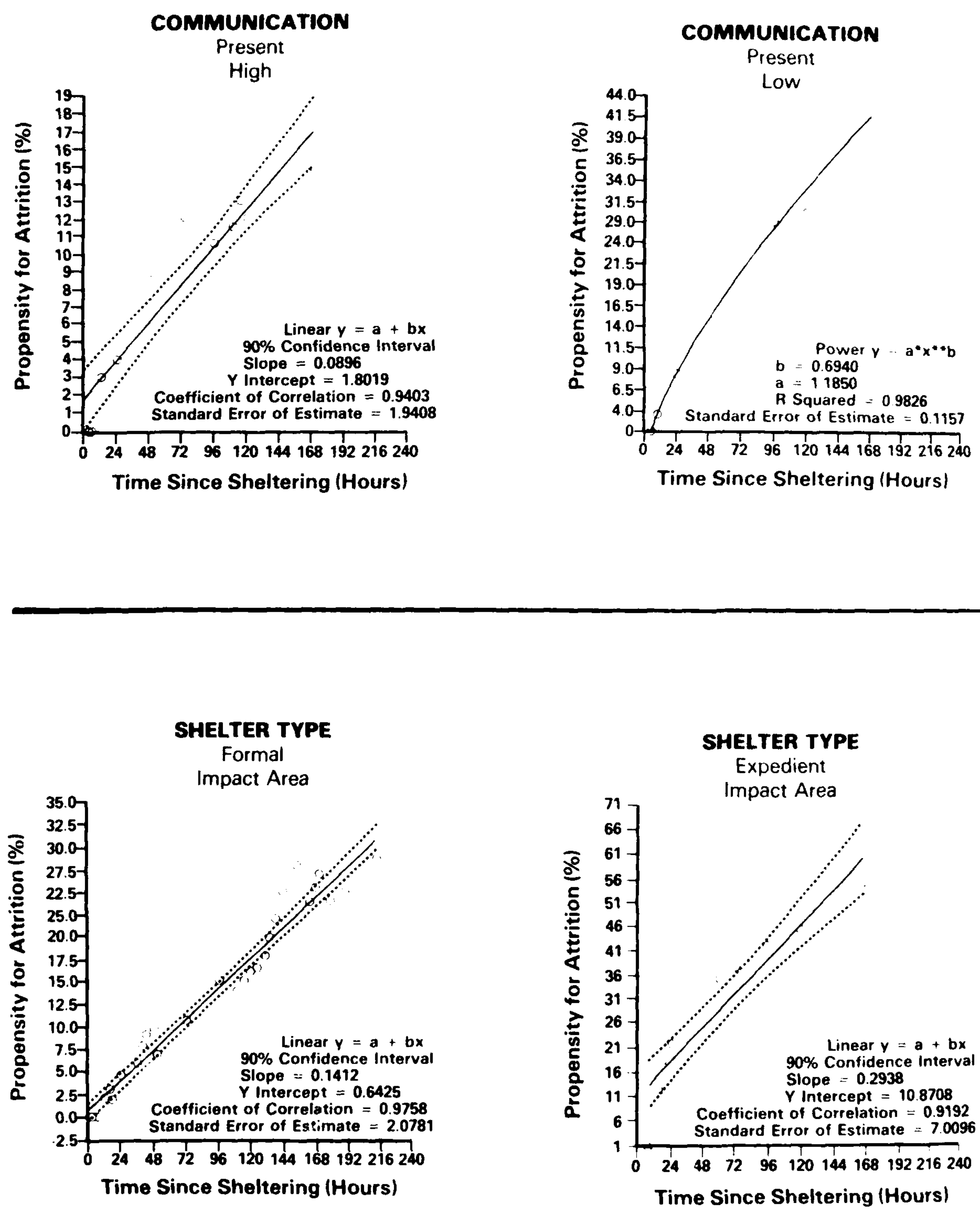
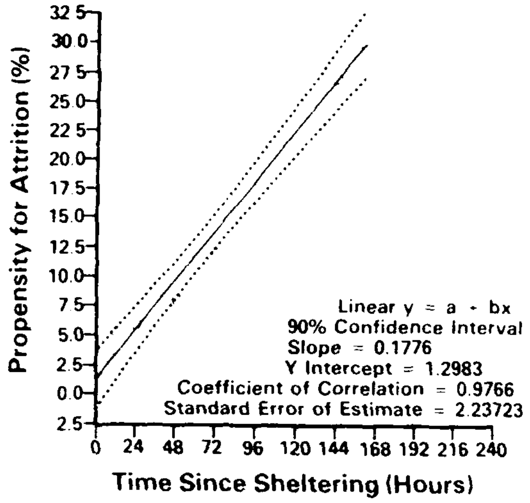
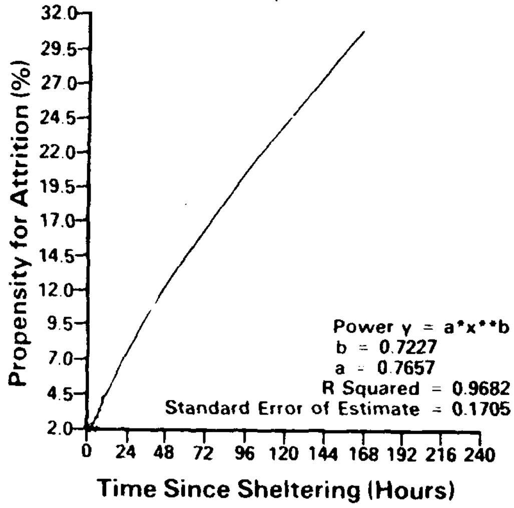


Figure 2-2. Graphs of the general attrition rate equations (continued).

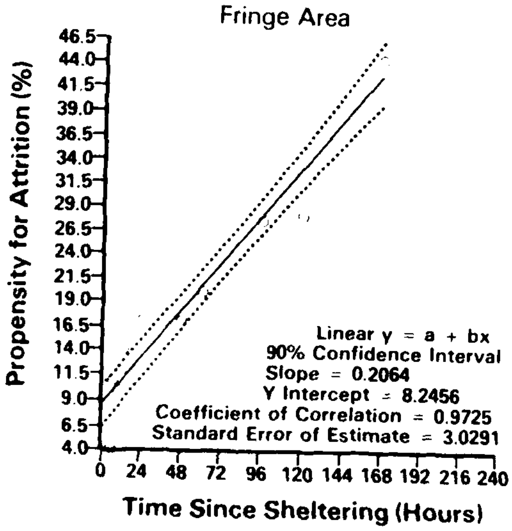
COMMUNICATION
Absent



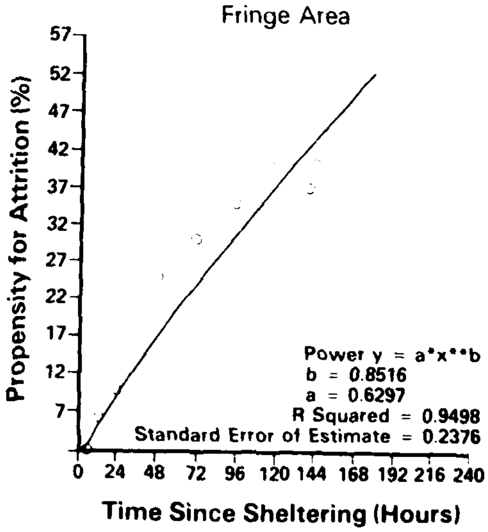
EVACUATION POSTURE
Non-Evacuated
Impact Area

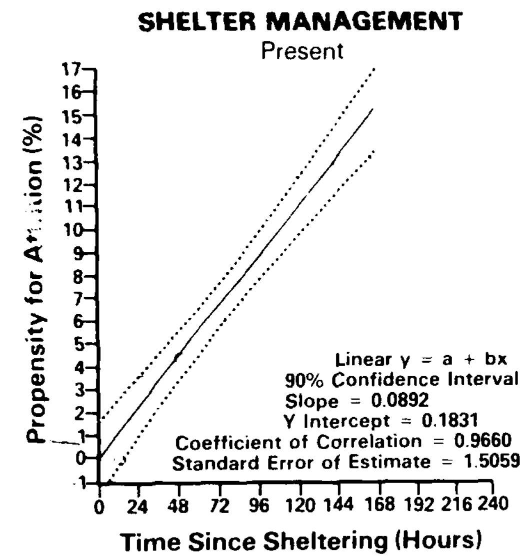


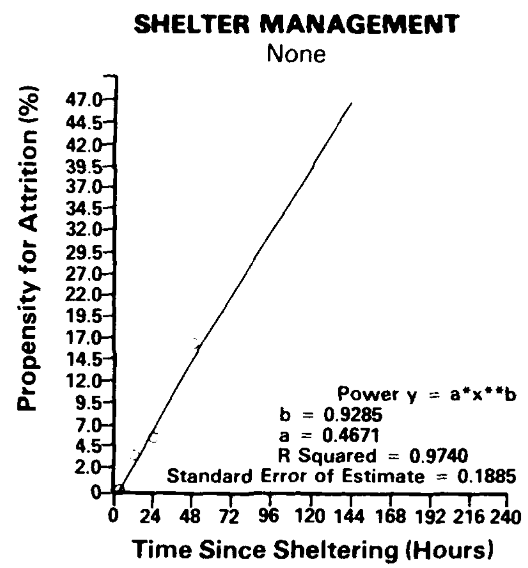
SHELTER TYPE
Expedient
Fringe Area



EVACUATION POSTURE
Evacuated
Fringe Area







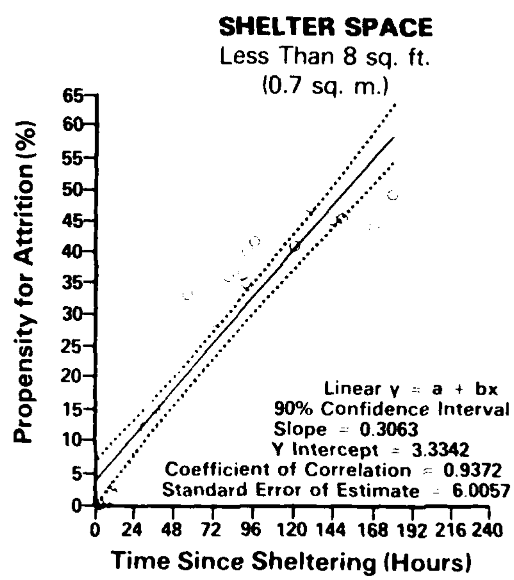


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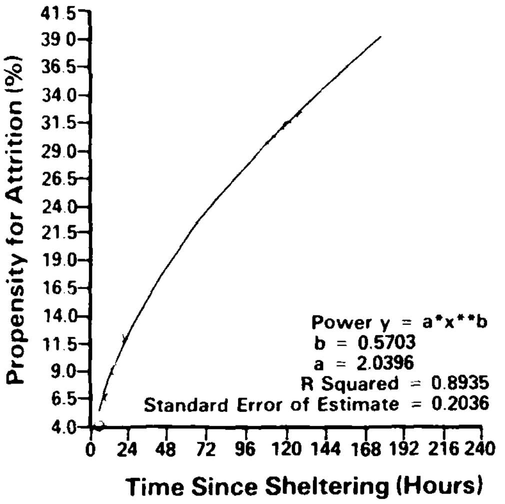
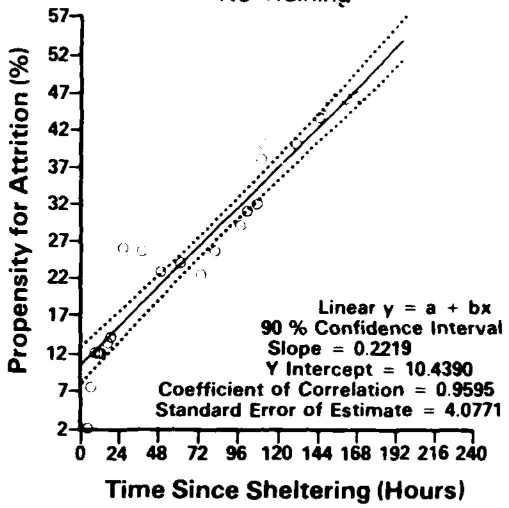
Figure 2-2. Graphs of the general attrition rate equations (continued).

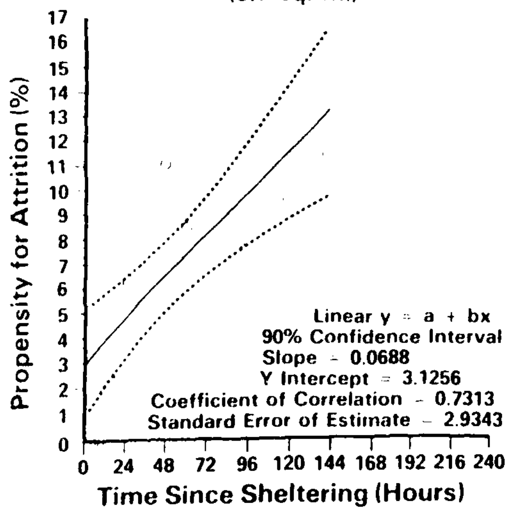
TRAINING
Trained



TRAINING
No Training



SHELTER SPACE
Greater Than 8 sq. ft.
(0.7 sq. m.)



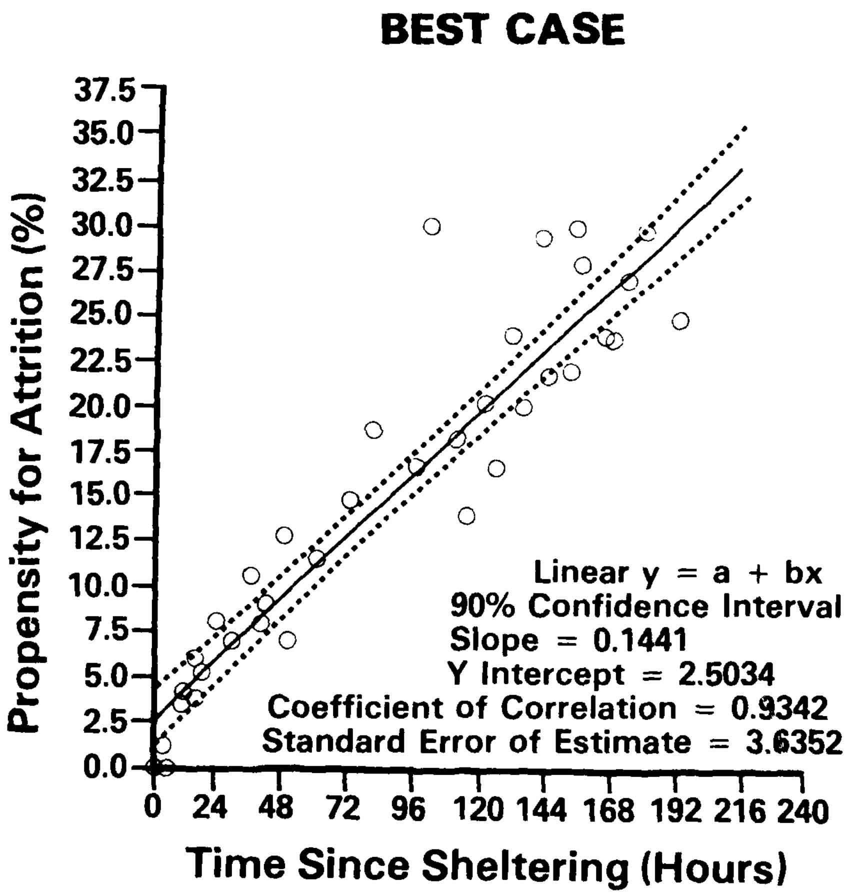


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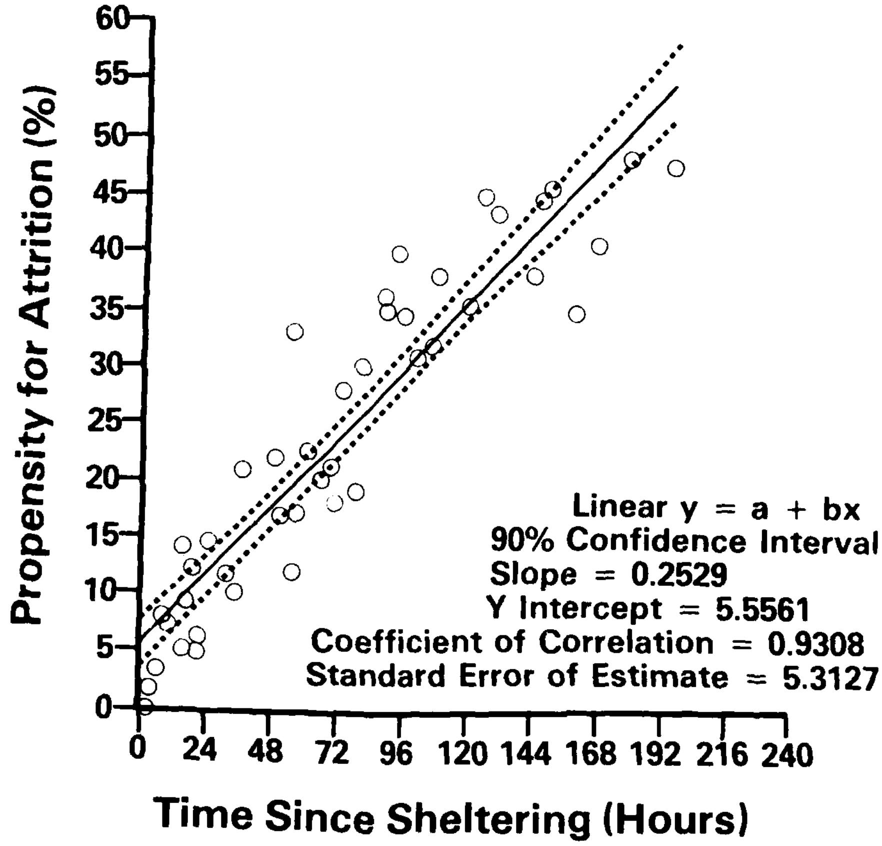
Figure 2-3. Graphs of the attrition rate equations - Best and Worst cases

WORST CASE



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and shelter space, and the presence of warned, trained, and well managed shelterees with adequate communication. The Worst Case is depicted in Figure 2-3b.

To complement the quantitative stay time data employed in construction of the Attrition Rate Model, qualitative behavior profiles and motivations for shelter exit as a function of time were also derived from the literature surveyed. These are summarized in Table 2-2 for the first seven days following the attack Generally, post attack behavior falls in the range considered normal. As shown in the table, reasons for shelter exit include: physical and physiological effects, such as shelter damage and lack of food, water, plumbing, etc,; lack of communication and direction; concern for relatives and friends; boredom; the desire to explore the external environment; the perception of the danger being over; and the need for action.

2.4 DISCUSSION

The Attrition Rate Model, as denoted in this study, is the response depicted in Figure 2-2. Based on the systematic review of behavioral science source literature and the development of a database of quantitative stay time estimates, the model indicates that the expected behavioral response of a sheltered population is one of constant "attrition" from the shelter environment. This is to be contrasted with traditional assumptions in which the population is taken to be either completely in or completely out of their protective shelters at any one time.

Because of its foundation in a quantitative, empirical database, the Attrition Rate Model lends more justification to its use as a fallout shelter stay time assumption then do currently employed assumptions which vary widely in their definition, and which represent merely reasonable or convenient model imputs. The model provides a significant refinement of fallout shelter stay time representation, and contributes to the reduction in variability of the total number of simulation fallout injuries and fatalities characteristic of the range of stay time assumption currently

Table 2-2. Behavioral profiles and reasons for shelter exit.

TIME	BEHAVIORAL PROFILE	REASONS FOR LEAVING	PERCENT LEFT BEST CASE	PERCENT LEFT WORST CASE
Preattack	Aware concerned Unfocused Actions	-	-	
Attack	Dazed Muted Stereotypical	-	-	
Day 1	Fuzzy Anger/Frustration Rigidity	Physical Effects Lack of Communication Lack of Direction	5.9	11.6
Day 2	Difficulty Solving Problems Fear/Anxiety Manifestations of Boredom	Physical Effects Physiological Needs Lack of Communication Lack of Direction Primary Group Separation	9.4	17.7
Day 3	Cognitive clearing Anxiety Reduction Tension Reduction	Physiological Needs Primary Group Separation Need for Action	12.9	23.8
Day 4	Normal Tension/Irritability Reactions to Forced Idleness	Need to be doing something Judgment that danger was passed Organized Activity	16.3	29.8
Day 5	Normal Irritability Organized Activity	Lack of Communication Independent Judgment Primary Group Separation Physiological Needs	19.8	35.9
Day 6	Normal Acceptance Differentiation of Activities	Exploration of Environment Primary Group Concern Exhaustion of Resources Rescue Efforts	23.2	42.0
Day 7	Normal Directed Organized Activities	Perception of Danger over Need for Action Re-establish Community Exhaustion of Physical Resources	26.7	48.0

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employed. Although the model is based on criteria which attempt to approximate as closely as possible a post-attack environment, and upon a database which was specifically sought to reflect behavioral response due to real external threats and a spectrum of shelter types, application of the model to situations exceeding the characteristics of its database must be made with care.

For example, the Attrition Rate Model is based on data almost entirely representative of American response to disaster. Thus, application of the model to, say, the Soviet population entails a cross-cultural extropolation and assumption. One may estimate that the commonality of human response to disaster is such that all cultural response will lie somewhere within the Best and Worst cases displayed by the model. However, in the absence of additional data, this must remain an assumption. In addition, the model displays a clear distinction between the response of well-trained, well-equipped, and well-managed shelterees and the response of those ill-suited in these areas. Thus, any determined or overt program which tends to significantly accentuate these positive attributes prior to sheltering may condition behavior atypical of that displayed by the database employed. However, the methodology employed in constructing the model is largely independent of the database compiled; just the question of data availability remains. In constructing the Attrition Rate Model, only American disaster data were available.

Because the model indicates a continuous attrition of the shelterees from the shelter environment, application of model results within strategic simulations will require some process of discretization. In addition, among the eight categories of data identified, only responses characteristic of bi-polar parameters were developed. For example, for the case of training, responses reflecting either "presence of training" or "absence of training" are represented. Thus, the model does not characterize response as a function of <u>degrees</u> of training, or <u>levels</u> of communication, or <u>completeness</u> of warning, etc. However, aside from issues of model domain application of the model itself within currently employed

strategic simulations is envisioned as a straightforward exercise, involving at most computational and integration effort.

Consequently, the Attrition Rate Model is presented in this study as an "experimental tool" for use by strategic analysts in evaluating fallout casualties in nuclear exchange simulations. For this purpose, the remainder of the report focuses on the detailed use of the model in simulations exhibiting various levels of detail. In particular, two applications are presented: model use in a "pencil-and-paper" study of fallout casualties in Tbilisi, Soviet Georgia, and model use in SIDAC.

SECTION 3

APPLICATIONS OF THE ATTRITION RATE MODEL

The usefulness of the Attrition Rate Model of fallout shelter stay times developed in the previous section as a tool for the investigation of fallout casualties in strategic simulations is illustrated in this section. First, a generic guide for the application of the model is presented. This guide provides a framework within which strategic studies at various levels of detail can make use of the model. Application of the model, and use of the guide, is then presented by means of two examples: first, a 'pencil-and-paper' study of fallout casualties in Tbilisi, Soviet Georgia, and second, a study of casualties using the SIDAC simulation model.

3.1 A GENERIC GUIDE TO THE USE OF THE ATTRITION RATE MODEL

This section describes, in general terms, procedures for the implementation of the Attrition Rate Model in the calculation of strategic fallout casualties. The steps as described below were performed in the Tbilisi study. In the SIDAC study, only the last step was specifically performed; the remainder are performed automatically in the SIDAC simulation itself.

The necessary steps are as follows:

(1) Determine the expected distribution of the post-attack population among fallout shelters.

(2) Generate the weapon laydown and develop the resulting blast and fallout contours.

(3) Identify those shelters destroyed by blast, and the distribution of surviving shelters among fallout radiation field intensities.

(4) Employing the Attrition Rate Model, determine the radiation dose received by each individual as a function of his shelter protection factor and the intensity of the local fallout field.

(5) Compute casualties based on dose received.

These guidelines are purposefully general in order that they may be applicable over a wide range of simulation detail. In the examples to follow, use of the model is keyed to investigating the sensitivity of the total number of fallout casualties to variations in stay time assumption.

3.2 FIRST MODEL APPLICATION: TBILISI, SOVIET GEORGIA

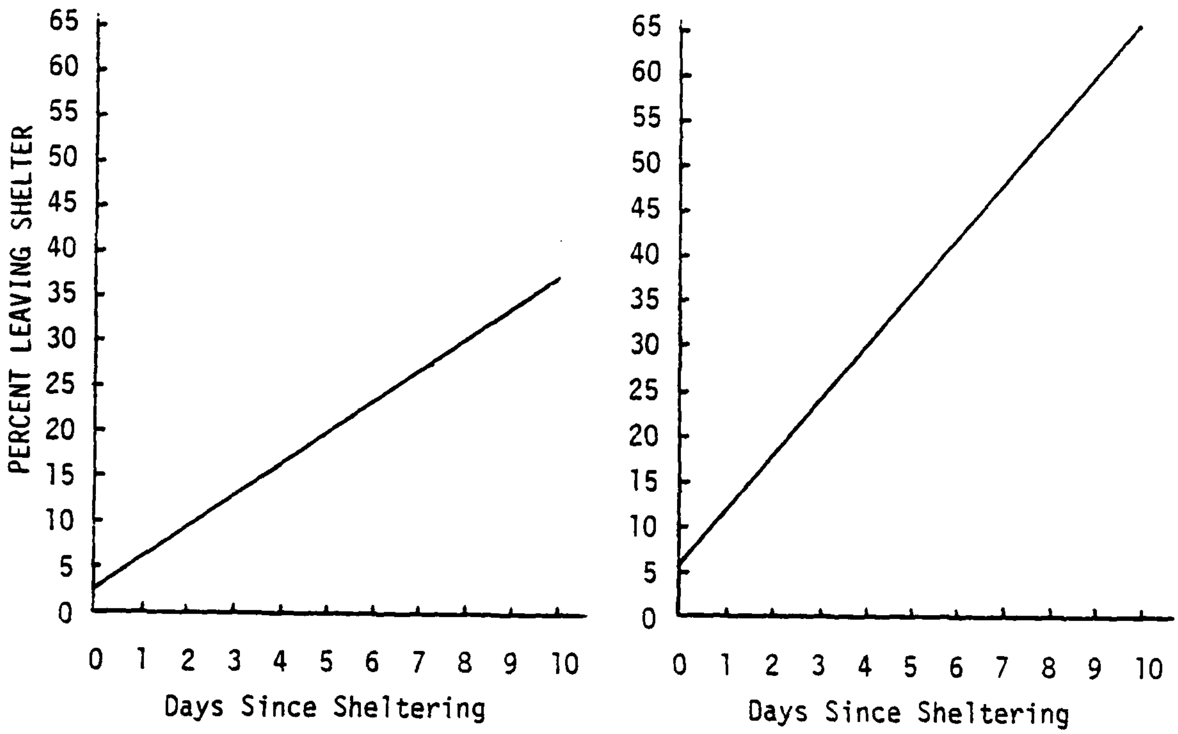
The study of a simulated laydown pattern on Tbilisi, Soviet Georgia, was a preliminary pencil-and-paper study to demonstrate the use of the model. The goal of the study was to compare results for two traditional stay time assumptions with the results for the new Attrition Rate Model. The two traditional assumptions investigated were the Seven Day assumption (7 days in, 14 days 2/3 in) and the Two Day assumption (2 days in, 3 days 2/3 in). These were compared with the Best and Worst Cases from the Attrition Rate Model. The Best and Worst Case attrition rates are shown in Figure 3-1. Only a summary of the study is given here; further details may be found in (3).

3.2.1 Assumptions

In order to perform the comparison, all assumptions of the model except that of shelter stay times were held constant. For the hypothetical attack, the laydown consisted of twelve strategic RVs targeted on significant industrial or military targets in and around the city. Six RVs were employed as ground bursts; the remaining six RVs were air bursts. A simultaneous burst laydown was assumed.

The fallout was caused by a 20 knot wind blowing northwest, a direction characteristic of the area between November and April. Fallout was assumed to arrive at 1.5 hours. (This is reasonable, as we only considered the casualties within the city; downwind rural casualties were not investigated).

The distribution of population among shelters of various PFs and the shelter blast vulnerabilities were taken from an SRI study (4). The shelters were assumed to be uniformly distributed within the city boundaries. The outside protection factor was assumed to be PF=2.



Best Case

$y = 2.5 + 3.5t$

Trained
Warned
Food and Water Generally Available
Formal Shelters
Sufficient Space
Well Managed
Outside Communication is Possible

Worst Case

$y = 5.5 + 6.0t$

Not Trained
Short Warning Time
Food and Water Supplies are Low
Informal Shelters
Cramped Surroundings
No Shelter Management
No Outside Communication

Figure 3-1. The best and worst case attrition rate models.

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To estimate shelter destruction by blast damage, the DIA blast vulnerability methodology (Physical Vulnerabilties Handbook (5)) was used. Fallout radiation fields were modeled using the EM-1 fallout methodology (6). Fallout was assumed to decay as $t^{-1.2}$, with t in hours.

The number of casualties was equal to:

N= (1/4)·(individuals receiving between 250R and 450R)

+(3/4)·(those receiving between 450R and 650R)

+(1.0)·(those receiving over 650R)

All doses were received within ten days, and in most cases the majority of the dose was received within four days, so no biological repair factor was needed or used.

For ease of computation, attrition from fallout shelters was assumed to take place at 24 hour intervals, rather than continuously. This introduces no significant change in the results.

3.2.2 Approach

To estimate the variation in sheltered population fallout casualties in Tbilisi for each of the stay time assumptions, a two part approach was employed.

In the first part, the number of casualties per day was computed for shelters with PFs of 10, 50, 100, 200 and 500 located in fallout fields ranging in intensity (at one hour) from 300 to 10,000 rads per hour. Casualties were computed for the four different stay time assumptions: Seven Day, Two Day and the Best and Worst Cases from the Attrition Rate Model.

In the second part, a hypothetical attack on Tbilisi was considered. A laydown pattern was generated as discussed above. The resulting blast damage to shelter was computed using the Physical Vulnerabilities Handbook. Figure 3-2 shows the city boundaries and regions of shelter destruction. Fallout contours were constructed using EM-1 methodology. In Figure 3-3 the radiation field resulting from the laydown is presented. The fraction of surviving (undamaged) shelters in each radiation field was computed by overlaying each part of Figure 3-2 with Figure 3-3 and computing the area contained in each field. The resulting number of daily fallout casualties

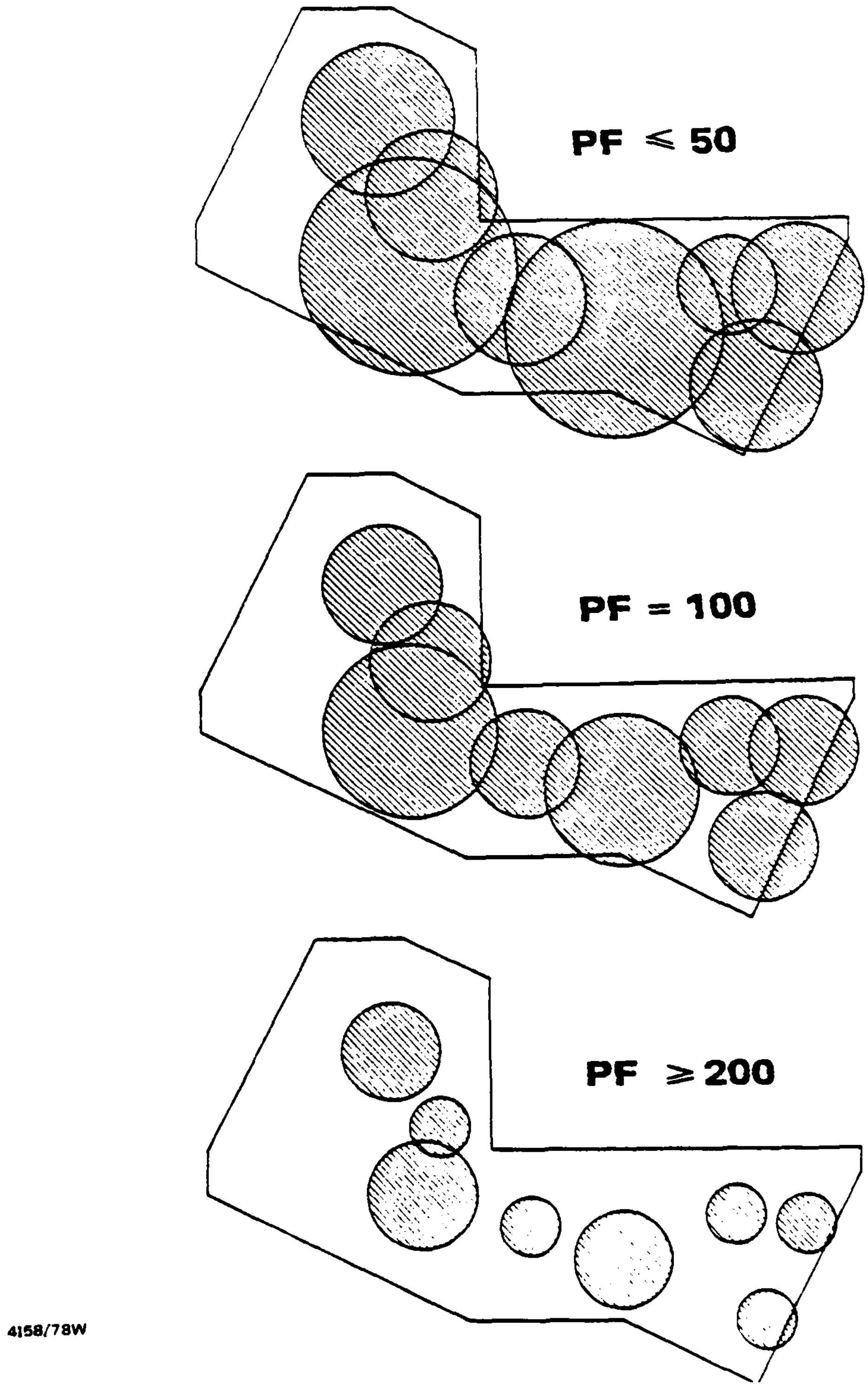

Figure 3-2. Tbilisi city boundaries and regions of total shelter destruction.

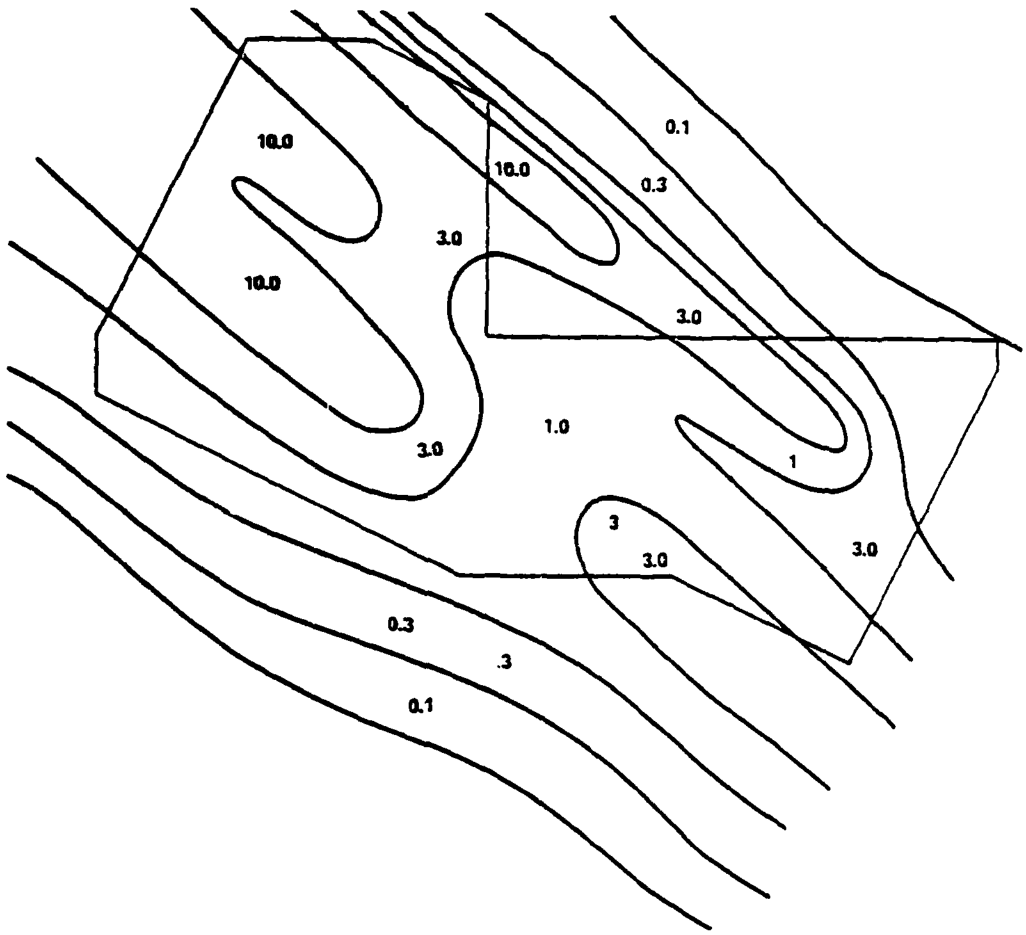

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Figure 3-3. The fallout field of Tbilisi in thousands of rads per hour at one nour.

was then determined by estimating the percent of undestroyed shelters in fallout fields of intensity 300 to 10,000 R/hr, and employing the results of part one.

3.2.3 Results

Part one resulted in four graphs for each protection factor: one graph for each of the four possible stay time models. As an example, Figure 3-4 presents the results for PF=200. (Complete results may be found in (3)).

Note that the two versions of the Attrition Rate Model yield relatively smooth curves. This is because of the continuous outflow of shelterees under this model. The traditional assumptions, on the other hand, are much more jagged. In fact, by definition these curves can only take values of 0, 25, 75 and 100 percent.

The results of part two are summarized in a series of tables. Table 3-1 provides a summary of the distribution of the sheltered population both before and after the blast. In Table 3-2 the population which survived the blast is distributed by percentage among the various protection factors and radiation fields. Figure 3-5 and Table 3-3 depict the final casualty figures. (Note: In Figure 3-5 and Table 3-3, a casualty is defined as one who has received a fatal dose, not necessarily one who has already died. The actual times of death might be later than depicted in the graphics).

3.2.4 Discussion

A number of conclusions may be drawn from Figure 3-4 and similar diagrams for other protection factors. Using the Two Day and Seven Day assumptions, no casualties result from a 300 R/hr or less radiation field. Under the Attrition Rate assumption, those people who leave shelter within the first few hours were casualties. (These individuals were assumed to be sheltered from the blast, but to leave shelter before the fallout arrived.)

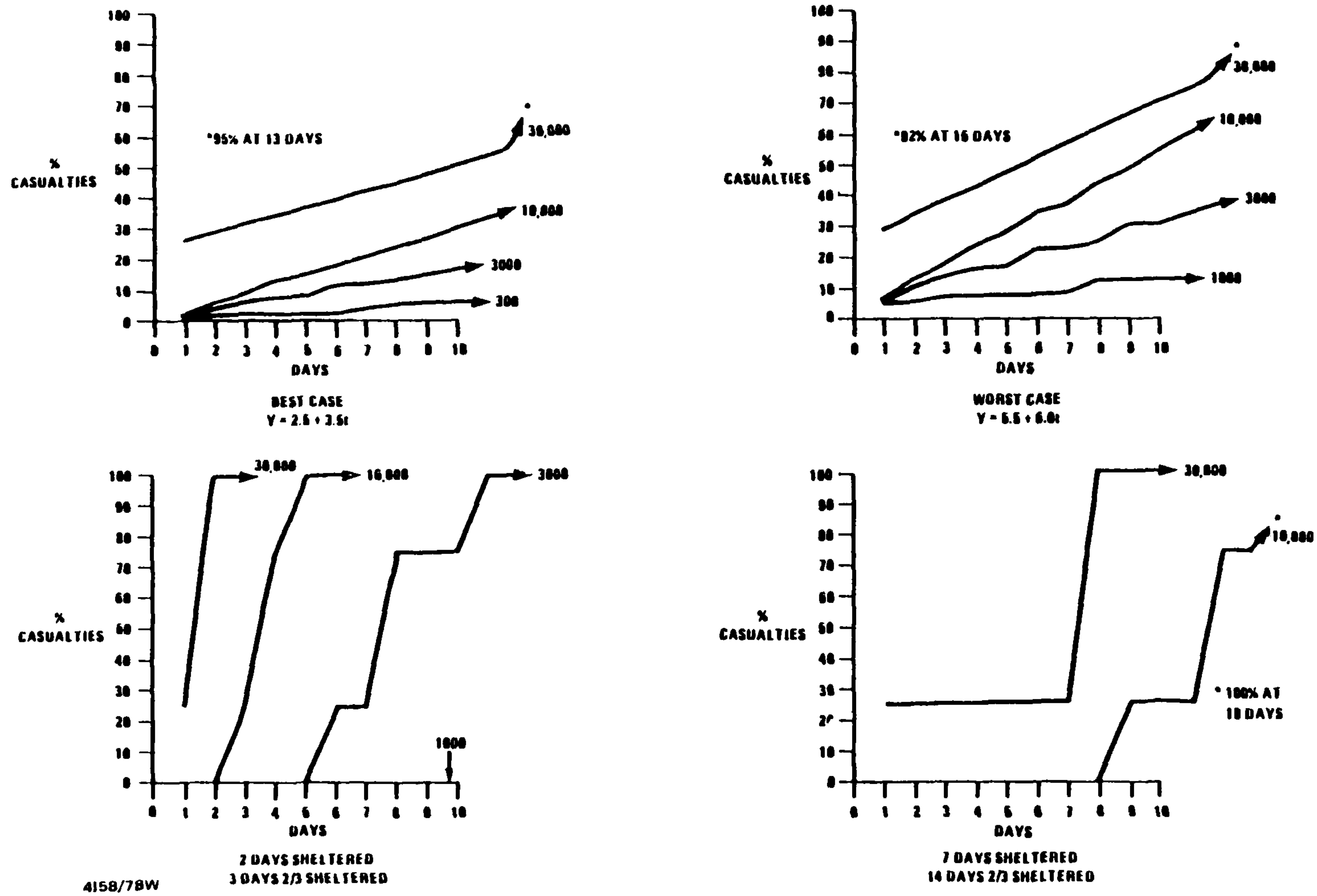

Figure 3-4. Daily casualities for the first ten post-attack days as a function of stay assumption and fallout radiation intensity (in rads/hr at one hour) for shelters with PF = 200.

Table 3-1. Summary of sheltered population distribution, blast damage, and distribution of surviving shelters in the Tbilisi fallout field.

PROTECTION FACTOR	PERCENT OF SHELTERED POPULATION	PERCENT OF SHELTERS SURVIVING BLAST	PERCENT OF POPULATION SURVIVING BLAST	PERCENT DISTRIBUTION OF SURVIVING SHELTERS IN FALLOUT FIELD				
				<300 R/H	300	1000	3000	10,000
10	14	24	3	3	1	27	27	42
50	26	24	6	3	1	27	27	42
100	18	44	8	4	2	37	30	27
200	30	74	22	3	7	40	30	20
500	12	74	9	3	7	40	30	20
	100		48					

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Table 3-2. Percentages of surviving sheltered population in Tbilisi in various shelters and fallout fields.

PROTECTION FACTOR,	FALLOUT INTENSITIES					TOTAL
	< 300	300	1000	3000	10,000	
10	.21	.06	1.89	1.89	2.94	6.99
50	.59	.12	5.44	3.44	5.35	12.74
100	.66	.33	6.01	4.87	4.38	16.25
200	1.38	3.19	18.28	13.71	9.14	45.70
500	.56	1.28	7.33	5.49	3.66	18.32
TOTALS	3.20	4.98	36.95	29.40	25.47	100.00

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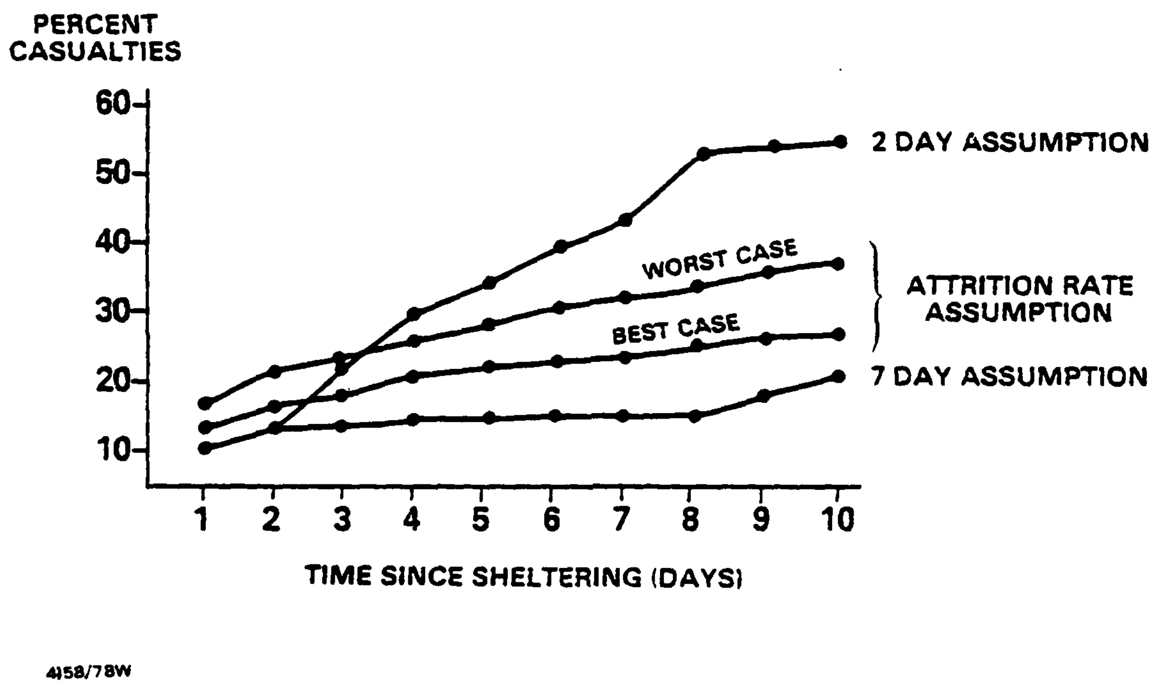

Figure 3-5. Daily percentage of sheltered Tbilisi population becoming casualities within the first ten days for each of the three shelter stay time assumptions.

Table 3-3. Fallout casualities in Tbilisi (percent).

DAY	ATTRITION RATE ASSUMPTION		TWO-DAY ASSUMPTION	SEVEN-DAY ASSUMPTION
	BEST CASE	WORST CASE		
1	8.0	11.2	5.7	5.7
2	12.4	16.5	8.8	8.8
3	13.9	19.0	17.2	9.3
4	16.4	22.3	25.5	10.4
5	17.1	23.4	29.9	10.4
6	18.5	25.8	34.7	10.4
7	19.4	27.4	38.9	10.4
8	20.8	29.8	48.5	10.4
9	22.2	32.1	49.3	14.0
10	22.9	33.5	50.6	17.2

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The major difference between the casualty curves for the tradinal and Attrition Rate assumptions occurs for high PF shelters. The traditional assumptions result in 100% casualties for those in high radiation fields, and 100% survival for those in low radiation fields. The Attrition Rate assumptions more realistically allow other than "all-or-nothing" choices. Casualties are higher in high fields than in low ones, but those people who remain in high PF shelters have a chance to survive in even the worst radiation fields.

As indicated in Figure 3-5, the percentage of post-attack casualties associated with the Attrition Rate stay time assumption is between 1.5 to 2 times greater than the percentage expected for the Seven Day assumption, and between 1/8 to 1/2 times less than casualties expected based on the Two Day assumption (after the fourth day). However, the Attrition Rate assumption is based on a survey of human behavioral response across a spectrum of shelter types, whereas the Two Day and Seven Day cases assume, respectively, shelters characterized by inadequate and generally adequate water availability and plumbing facilites. Thus, any comparison of these stay time assumptions must include the expected distribution of Two Daylike and Seven Daylike shelters within the country under attack.

According to the SRI study "Fallout Protection Factors for Various Countries" (4), shelters in the U.S. and Soviet Union are overwhelmingly of the Seven Day type. Two Daylike shelters are more prevalent in lesser developed countries such as Spain, Turkey, Romania, Hungary, etc. As a result, this analysis indicates that the "standard" stay time assumption for the U.S. and Soviet Union (i.e., Seven Day) probably underestimates post-attack casualties by between five and fifteen percentage points. In addition, as shown by the Worst Case and Best Case results of Figure 3-5, adequate training, warning, and general preparedness would reduce expected casualties between five to ten percentage points in Tbilisi. For a city of this size, this would represent approximately 60,000 civilians.

In some cases, an analyst would use both the Two Day and Seven Day stay times to investigate the variability of casualties as a function of stay time assumptions. There is a 250% difference between the Two Day and Seven Day results after ten days. The Best and Worst Cases, however, seem to reduce this variability to approximately 50%.

It should be noted that the calculations performed during this study have shown that the daily percentage of casualties expected for the Attrition Rate and Seven Day assumptions is a function of the shelter protection factor and the intensity of the local radiation field. That is, the conclusion cannot be made that for all PFs and fallout intensities, for example, the Attrition assumption will always generate more casualties than the Seven Day assumption. Consequently, the variation in casualties for each assumption is expected to be scenario dependent, requiring the inclusion of estimated shelter distributions within constructed fallout fields, and consideration of population allocations to those shelters.

In summary, the exemplative analysis of an attack on Tbilisi conducted for this study has shown:

(1) The number of post-attack casualties is expected to be scenario dependent;

(2) The inclusion of realistic behavioral assumptions in stay times (Attrition Rate assumption) generated 1.5 to 2 times more casualties in Tbilisi than the "traditional" assumption (Seven Day), and;

(3) Adequate shelter preparedness generated between 1/4 and 1/3 fewer casualties than inadequate shelter preparedness in Tbilisi.

(4) The Attrition Rate Model reduces the range of variability associated with stay time assumptions.

3.3 SECOND MODEL APPLICATION: SIDAC

3.3.1 The SIDAC Model

SIDAC is a computerized analytical model designed to provide nuclear damage anlaysis information for both Red and Blue resource monitoring. It is a one-sided model that simulates land, air, and sea forces, as well as civilians and paramilitary. It can consider weapons or weapons systems individually and the modularity of its design allows the user to aggregate up to any level he wishes, depending upon his specific requirements. The model uses a mixture of deterministic and stochastic elements. Probability is used as the primary solution technique for prompt damage by means of the methodology developed by the Physical Vulnerability (PV) Division of the United States Air Force Intelligence. Delayed radiation effects are estimated by means of the methodology developed by the Weapons Systems Evaluation Group (WSEG).

SIDAC was developed by the Command and Control Technical Center (CCTC) of the Defense Communications Agency. It is used by the Studies, Analysis, and Gaming Agency (SAGA) under the aegis of the Joint Chiefs of Staff.

The structure of SIDAC is summarized in Figure 3-6. Inputs to SIDAC consist of the strike tape (containing the weapon laydown and related weapon information), wind and weather conditions, and the data base, containing target and population information.

SIDAC uses this information to produce an Answer File, often designated by File Code 25. For our purposes, we may consider the Answer File to have one "record" (unit of output) for each possible environment. An environment may be considered to be a group of fallout shelters (of varying PFs) in a given radiation field with a given probability of blast damage.

A record contains basic identification data, such as the country and geopolitical region of the information and whether it is in an urban or rural environment. Also included are the capacity of the shelter (CAP), the probability of receiving less than moderate or severe blast damage (MPROB and SPROB, respectively), and the maximum cumulative biological dose (MAXDOS) which would be obtained by an individual in that environment with no fallout shielding (PF=1).

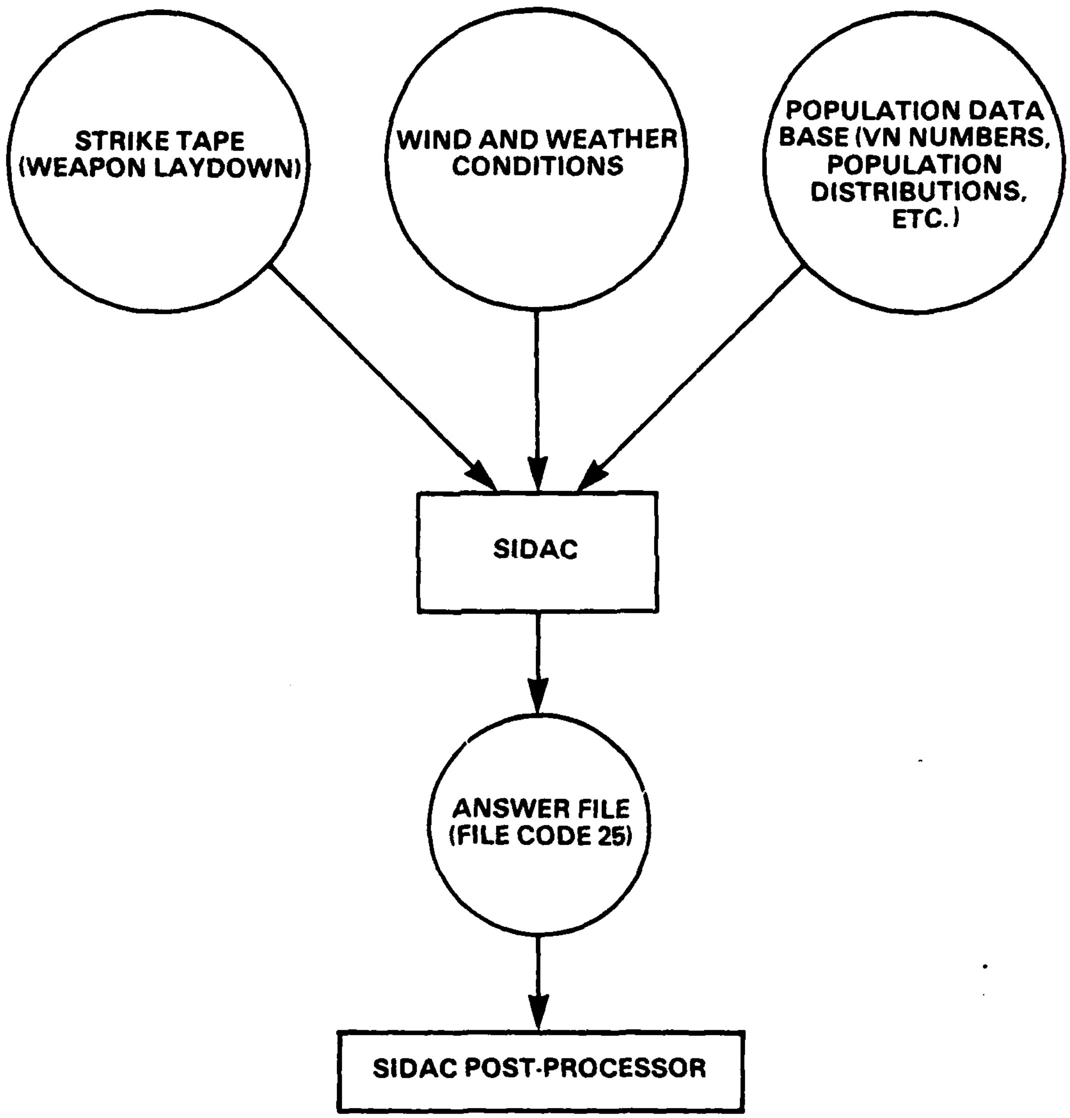

Figure 3-6. SIDAC structure and information flow.

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3.3.2 The SIDAC Post-Processor

The SIDAC post-processor performs the actual computation of prompt and fallout casualties. The post-processor as originally developed by CCTC consists of approximately 350 lines of FORTRAN code. A listing is contained in Appendix C. This program uses the SIDAC Answer File as input and produces casualty estimates for the scenario under consideration.

As originally configured, the post-processor allowed the user to input a shelter stay time assumption to apply to the entire population. This stay time is described in two parts: the period from time 0 to time ITT represents the period of 100% shelter occupancy. The period from ITT to JTT represents the period of partial shelter occupancy. The fraction of time the shelter is occupied is designated XMULT. After time JTT, radiation exposure was assumed to drop to zero. This is due either to evacuation of the area at risk or actual decay of radiation levels to below noticable limits.

An example will serve to clarify this. Assume we want to investigate the effects of a 7 day shelter stay time followed by 14 days of two-thirds sheltering. After 21 days, evacuation takes place. All times must be in hours. Therefore, we set ITT = 7 x 24 = 168 hours, JTT = 21 x 24 = 504 hours and XMULT = .667. With these inputs, the program would calculate the resulting casualties. Further details are contained in Appendix B.

3.3.3 The Modified Post-Processor

The post-processor as described above was modified to allow a linear attrition rate of y = at + b, as described in the Attrition Rate Model, with t = time in hours and y = proportion leaving shelter. The modifications will be described in brief here and more fully in Appendix D.

The Attrition Rate Model calls for a continuous flow of shelterees from the shelter. For computational purposes, this was approximated by a discrete model with one exodus from the shelters every 24 hours. For example, consider the linear attrition equation y = .0015t + .025. In this case, 2.5% of the shelterees leave immediately, and an additional .0015 x 24 = 3.6% of the shelterees leave every 24 hours.

To implement this model, a loop was inserted in the original program. ITT was started at 0 and incremented by 24 hours for each new day's population leaving shelter. JTT was held fixed at 504 hours (21 days) as it always was in the original version. The Attrition Rate Model makes no allowance for partial sheltering, so XMULT = 0.

For each value of ITT, casualty computations were made as in the original post-processor. In this case, however, the casualty figures were multiplied by that fractions of the population actually leaving shelter at time ITT. The casualties for groups leaving shelter on each day were summed to give the total casualty figures.

Again, an example will serve to clarify matters. Consider, for simplicity the attrition rate equation $y = \frac{.25}{24}\ t + .10$, with t in hours. This says that 10% of the population leaves shelter immediately, and an additional 25% leaves every 24 hours until the shelters are empty. After 72 hours, 85% have left. On day 4 (96 hours) the remaining 15% leave. We further assume that the radiation field is such that 100% of those leaving immediately die, as do 60% of those leaving after 1 day, 40% of those leaving after 2 days, 20% of those leaving after 3 days, and 10% of those leaving after 4 days. Consider a sheltered population of 1000 people. Table 3-4 summarizes the calculations. Out of 1000 people, 415 became fatalities.

The modified post-processor calculates casualties for an arbitrary attrition rate y = at + b. The two required inputs are the parameters a and b. The modifications to the original code consist of approximately 25 lines out of 350. The modified post-processor appears in Appendix D.

3.3.4 Method of Determining Casualties

The original and modified post-processors use almost identical methods to compute casualties. In fact, the only difference is that the modified version multiplies casualties from a given day's attrition by the proportion leaving on that day and then sums across days; the original assumes all attrition occurs at once, and so only has one group to consider. Therefore, we only consider the method in the original post-processor.

Table 3-4. Casualty calculation for hypothetical attrition rate $y = 0.25t + 0.10$

DAY	PEOPLE LEAVING	x	FATALITY FRACTION	=	NUMBER OF FATALITIES
0	100		1.00		100
1	250		.60		150
2	250		.40		100
3	250		.20		50
4	150		.10		15
TOTAL	1000				415

All injury and fatality calculations are made for three time periods: 7 days, 30 days, and 180 days after the blast. Unlike the Tbilisi study discussed above, this program counted a fatality only when it actually occurred, not when the lethal dose was received.

Recall that each record in the Answer File describes one outside radiation field and level of blast damage. The population described in this record is assumed to be distributed among shelters of various PFs, as shown in Table 3-5.

The overall structure of casualty determination is:

(1) Compute the proportion of prompt fatalities and injuries based on probabilities of damage.

(2) For each radiation field and protection factor, compute the proportion of fallout fatalities and injuries.

(3) Multiply number of shelterees by proportion of prompt fatalities to obtain the number of <u>prompt fatalities</u>.

(4) Multiply number of <u>remaining</u> shelterees (not killed by prompt effects) by proportion of fallout casualties to obtain the number of <u>fallout fatalities</u>.

(5) Multiply number of <u>still remaining</u> shelterees by proportion of prompt injuries to obtain the number of <u>prompt injuries</u>.

(6) After subtracting the number of fatalities and prompt injuries, multiply the number of remaining shelterees by the proportion of fallout injuries to obtain the number of <u>fallout injuries</u>. Note: Steps 5 and 6 imply that joint prompt and fallout injuries are counted simply as prompt injuries.

(7) The uninjured, <u>healthy population</u> is the remaining population after subtracting all casualties.

(8) This procedure is performed for each data record, and the results are summed.

This procedure is described in more detail in Appendix B.

Table 3-5. Distribution of shelterees for urban and rural environments.*

URBAN		RURAL	
PF	PERCENT	PF	PERCENT
800	14	40	2
250	7	35	5
150	7	30	15
100	14	25	8
40	28	20	22
20	17	15	6
10	13	10	42

* These shelter distributions may be explicitly overruled by input data, but this was never done during our sample runs.

3.3.5 The SIDAC Run

CCTC provided a SIDAC Answer File for analysis. The scenario was based on a Soviet attack on the U. S. For classification reasons, details of the SIDAC scenario are omitted. Because of this, the actual casualty figures should not be considered as representative of all SIDAC runs. However, the relative spread of results is significant.

Fallout shelter stay times were varied to investigate the sensitivity of casualty figures to stay times. Nine different assumptions were used:

(1) 3/4 day fully sheltered, 20¼ days 2/3 sheltered

(2) 2 days fully sheltered, 19 days 2/3 sheltered

(3) 3 days fully sheltered, 18 days 2/3 sheltered

(4) 5 days fully sheltered, 16 days 2/3 sheltered

(5) 7 days fully sheltered, 15 days 2/3 sheltered

(6) 14 days fully sheltered, 7 days 2/3 sheltered

(7) 21 days fully sheltered

(8) Attrition rate Best Case, $y = .0014t + .025$, no partial sheltering 1/

(9) Attrition rate Worst Case, $y = .0025t + .055$, no partial sheltering. 1/

For all nine cases, radiation exposure is assumed to end at 21 days due to evacuation or the decay of radiation intensity to insignificant levels. Note that this means No. 7 is equivalent to indefinite sheltering.

It is instructive to consider alternative stay times that provide identical effective protection factors for the 21-day period. Some of these are shown in Table 3-6.

3.3.6 Results

The SIDAC data base assumes a total U.S. population of 214.6 million. Of these, 131.4 million are urban, while 83.2 million are rural. The post-processor provides separate casualty figures for the urban and rural populations.

1. For Nos. 8 and 9, t is in hours.

Table 3-6. Effective protection factors and equivalent exit days.

PF	10		100		250		800	
SIDAC STAY TIME ASSUMPTION	PF_e	EXIT DAY	PF_e	EXIT DAY	PF_e	EXIT DAY	PF_e	EXIT DAY
2 days fully sheltered, 19 days 2/3 sheltered	6.6	8.2	15	8.6	16	8.5	17	8.6
3 days fully sheltered, 18 days 2/3 sheltered	7.2	10.2	18	10.2	20	10.2	21	10.1
5 days fully sheltered, 16 days 2/3 sheltered	7.8	12.3	23	12.3	27	12.4	29	12.3
7 days fully sheltered, 14 days 2/3 sheltered	8.3	14.2	29	14.1	35	14.1	39	14.2

DEFINITIONS:

PF_e = Effective protection factor

Equivalent exit day = the day such that complete sheltering up to that day and no sheltering after it gives the same PF_e as the corresponding SIDAC stay time assumption.

ASSUMPTIONS:

Fallout arrives at 1½ hours

Outside PF = 1/.65 = 1.538

The actual post-processor output is provided in Appendix E. This section contains a summary and analysis of the results.

Prompt fatality calculations are independent of subsequent fall out shelter stay times. Therfore, every set of results has the same number of prompt fatalities. For this scenario, 92.1 million of the urban population (70.1%) and 7.5 million of the rural population (9.0%) were prompt fatalities.

Prompt injuries are slightly dependent on fallout sheltering. (A prompt injury can become a fallout fatality, and this can happen at different times for different levels of sheltering.) However, the figures are relatively constant over time and for each scenario. For comparative purposes, figures of 23.0 million urban prompt injuries (17.5%) and 11.5 million rural prompt casualties (13.8%) were used. Actual results differed from these by no more than two or three percentage points. The actual results are available in Appendix E.

The post-processor provides casualty figures for three different points in time: 7 days, 30 days, and 180 days after the attack. Fallout fatalities and injuries are assessed on the basis of maximum biological dose (MBD) received. In cases of shorter shelter stay times (less than 5 days) this MBD is received before the seventh day, and so the 7 day casualty figures are accurate. However, for longer stay times, this MBD is not received until sometime after seven days have elapsed, so the 7 day fallout casualty figures are inaccurate.

Because of the high percentage of prompt casualties, only a small fraction of the total population was at risk (i.e., alive after the blast) for fallout casualty calculations. In addition this fraction was different for urban and rural populations. Therefore, in presenting fallout fatalities, the percentages were normalized to the population at risk by dividing by the fraction of population which were not prompt fatalities. Similarly, for fallout casualties, the percentages were normalized by dividing by the fraction not prompt fatalities <u>or</u> injuries.

With these points in mind, consider the casualty figures presented in Figure 3-7 and 3-8. Figure 3-7 presents fallout fatalities for the nine stay times and for both the urban and rural populations (left and right graphs, respectively). Figure 3-8 presents similar information for fallout injuries.

Notice that the error in the 7 day figures discussed above is readily apparent. If there were no error, the 7 day, 14 day, and 21 day stay time figures would be identical. The differences demonstrate that the MBD is not always received by the seventh day.

These graphs effectively illustrate the major goal in developing the Attrition Rate Model: reduction in variability associated with sheltering estimates. At 180 days, there is a 500% difference in urban fatalities and a 250% difference in rural casualties between the 21 day full sheltering assumption and the 3/4 day full, 19¼ day 2/3 sheltering assumption. The difference between the Best and Worst Case is roughly 50% for urban fatalities and 25% for rural fatalities. Similar relative differences, although much smaller in actual numbers, exist for the injury graph.

The Worst and Best Cases are approximated by the 2 day fully sheltered, 19 day partial sheltered and the 3 day sheltered, 18 day partial sheltered assumptions. However, note that from Table 3-6, the 2 day sheltered, 19 day partially sheltered stay time provides the same protection as an 8.6 day fully sheltered stay, followed by 12.4 days out in the local radiation field (for a total of 21 days) before evacuation. The 3 day sheltered, 18 day partially sheltered stay time is equivalent to 10.2 days in a shelter, followed by 10.8 days in the local radiation field before evacuation. These numbers indicate that care must be exercised in attempting to compare results of the Attrition Rate Model with one "equivalent" stay time; there are many combinations of stay times which provide equivalent protection.

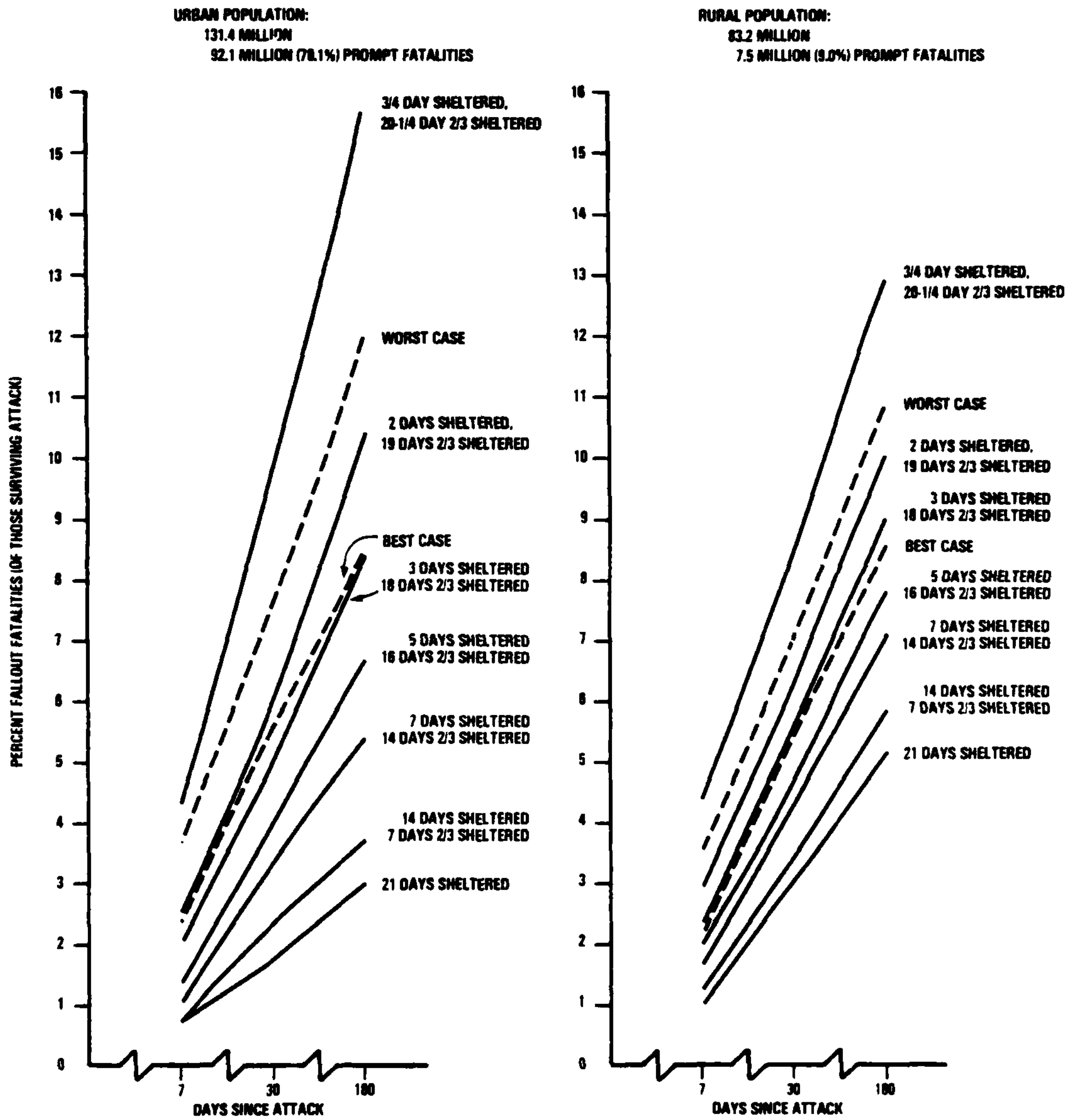

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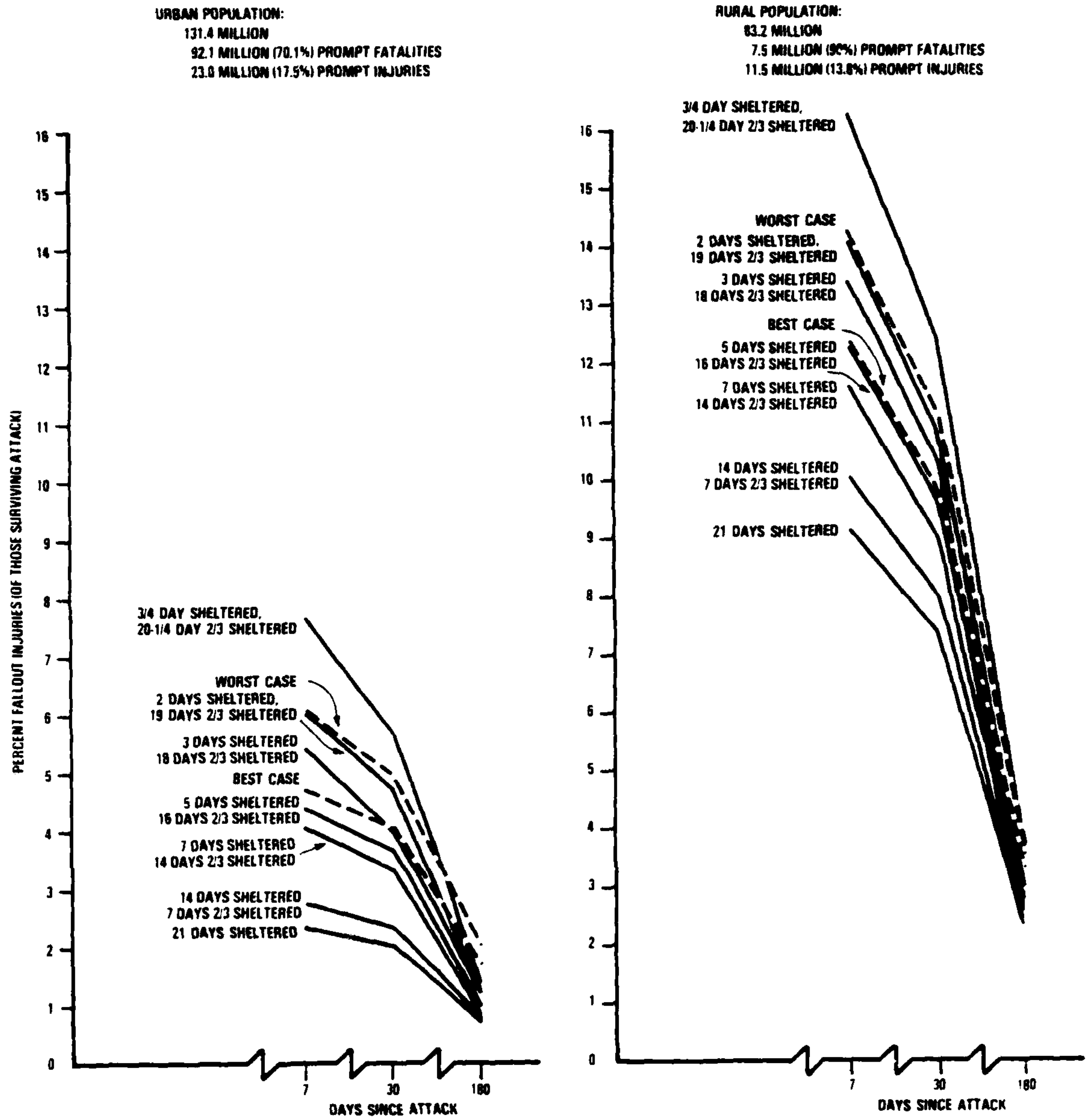
Figure 3-7. Fallout fatalities for urban and rural populations.



NOTE: Those with both prompt and fallout injuries are counted as prompt injuries only

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Figure 3-8. Fallout injuries for urban and rural populations.

There is a significant difference in the computer time needed to perform these runs. The runs were made on a Honeywell 6000 series computer running under the GCOS operating system. A single run of one of the Attrition Rate assumption took roughly 9 times longer than a single run of one of the traditional stay time assumptions. However, recall that the post-processor was designed to work for the traditional assumptions, and "brute force" was used to make it handle the Attrition Rate assumptions. A program properly designed specifically for the Attrition Rate assumptions could be expected to improve on these figures considerably.

The Best and Worst Case results are roughly parallel to the more traditional stay time results on each of the four graphs. They also lie roughly in the same range, i.e., near the results for 2 day and 3 day stay times. However, all four graphs come from only one SIDAC scenario, one with a very large proportion of blast casualties. One may hypothesize that these relationships hold in general for other scenarios, or that the 3 day fully sheltered, 18 day partially sheltered stay time, for example, produces the same number of casualties as the Best Case. To date, these conjectures remain just that, and further work is needed to substantiate them.

3.4 SUMMARY

The Attrition Rate Model displays three advantages as a tool for the investigation of fallout casualties. First, it has a basis in a real data base analyzed using the methods of the behavioral sciences. As such, it provides a justification for the use of model stay times; a justification absent in previous stay time assumptions. Second, the Attrition Rate Model reduces the variability associated with a variety of shelter stay times. Third, the methodology used to derive the Attrition Rate equations can be applied to a variety of behavioral problems. If appropriate data bases are available, one may apply these methods to develop empirical models in other fields.

SECTION 4
FURTHER APPLICATIONS

Among the initial objectives of this study was the development of a tool for use in strategic simulations with the purpose of reducing the variability in simulated results supported by the "human element". The Attrition Rate Model represents such a tool with respect to fallout shelter stay times. In the previous section, two applications of the model were presented. These applications focused on an investigation of the sensitivity of fallout casualties to stay time assumption. In this chapter, additional applications of the model are suggested. These include extensions of the type of research exemplified by the applications in Section 3, as well as more detailed use of the model.

4.1 IMPLEMENTATION OF THE COMPLETE SET OF ATTRITION RATE EQUATIONS

The first application is to modify the SIDAC post-processor (Appendix D) to accept the complete set of 24 different Attrition Rate equations. These equations were previously presented in Table 2-4.

There are two distinct parts to the modification, corresponding to the two different functional forms of equations. For the linear equations ($y = at + b$) almost no modification is needed. The program is already designed to handle the two linear equations describing the Best and Worst Cases. The only required inputs are the parameters a and b (designated AA and BB in the modified code, Appendix D). By inputting the proper a and b, the current post-processor will handle any of the linear equations.

Of the 24 equations, 5 take the simple exponential form $y = at^b$. This is slightly more difficult to handle in that the code as currently structured cannot handle an exponential stay time. But the addition of this capability is fairly straightforward.

By adding this capability, variations in fallout casualties due to the range of response in each of the eight data categories summarized in Table 2-4 could be investigated. For example, the impact of training vs no training, or good shelter management vs poor shelter management on population

survival could be analyzed. With this information, the analyst could investigate each of the eight variables, rather than just the best and worst case summaries.

4.2 ADDITIONAL SCENARIOS

To date, only one SIDAC scenario has been run as described in Section 3.3. It is impossible to draw general conclusions about model behavior on the basis of one run. Many different scenarios must be considered and the variability of the results must be examined. In this way we can investigate various hypothesis about shelter stay times with range of scenarios could answer questions concerning:

(1) The existence of simple stay time assumptions "equivalent" to the Best and Worst Case Attrition Rate Model;

(2) The impact of the Attrition Rate Model assumption for various degrees of evacuation posture;

(3) The range of casualties between the Best and Worst case responses;

(4) The variation of fallout casualties under a variety of weapon laydown patterns; and

(5) Other hypothesis concerning the model.

It is a simple matter to implement this application. Each SIDAC run should be made in the usual way, generating an Answer File. This Answer File is then run through the modified post-processor and the results analyzed as in Section 3.3. These results will yield general rules which the Attrition Rate Model follows.

As an example, consider the claim that a 3 days sheltered, 18 days partially sheltered stay time yields casualty figures approximately equal to the Best Case. This is borne out in the one scenario that has been studied. Should this prove to be the case over a number of widely varying scenarios, we would consider the claim validated. If this claim were true, we could use it to an advantage. Recall the modified post-processor uses more computer time than the original. If we could model the Best Case results by using the 3 day stay time, we could simulate the use of the Attrition Rate Model while saving on computer expense.

4.3 OTHER SIMULATION MODELS

The post-processor presented in Appendix D is designed to work only in the SIDAC system. However, there are currently a number of other models within the defense community which are employed to estimate strategic fallout casualties. Among these are CIVIC, COBRA, READY, and RISK II. Through appropriate modifications these programs could be made to handle the Attrition Rate equations. In this way the Attrition Rate Model of casualty prediction could be more widely available for use throughout the community.

Because modifications to the SIDAC post-processor were straightforward (although by no means trivial), there is every reason to believe that a similar effort could be made to modify the casualty prediction sections of the other simulations. For example, in CIVIC (Civilian Vulnerability Indicator Code, (8)) the Attrition Rate equations should be inserted in Overlay (5,0), the Initial and Fallout Effects Damage Assessment Overlay, and more specifically, in Secondary Overlay (5,4), entitled EVAL5, Assess Casualties and Fatalities from Individual Weapons - Initial and Fallout Effects. Modifications to other simulation models should be quite similar.

4.4 ALTERNATIVE DATA BASES

The methodology outlined in Section 2 for the construction of the Attrition Rate model is not limited to one specific data base. For this study, data were extracted from readily available investigations of U.S. disasters and behavior. Thus, the model is most applicable to U.S. populations.

If a data base of Soviet disasters were available, one could reperform the analysis to obtain a similar set of equations based on Soviet psychological responses. This data would more accurately reflect those psychological aspects which differ in American and Soviet societies. With this data base one could feel more confident in making statements about the Soviet reaction to a nuclear disaster.

This technique is not limited to fallout shelter studies. If an appropriate data base exists, subjects such as industrial production under adverse circumstances or recovery after stress could be investigated.

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APPENDIX A

THE SIDAC INSTRUCTION SET

Table A-1 contains the set of instructions used by CCTC to generate the SIDAC run. It is presented here without comment. It may be of use to those familiar with SIDAC who desire to reproduce the results presented in this document.

Table A-1. The SIDAC instruction set (continued).

```
IF SCATCD NE '99999'. SET TARGEL=[illegible]
IF SGECPO EQ '4' AND SLOCIR NE 'OS'. SET TARGEL=[illegible]
IF SLOCIR EQ 'CY'. SET SGECPO=3
IF SGECPO EQ 'S'. SET SGECPO=4
IF SGECPO EQ 'T'. SET SGECPO=4
IF SCATCD EQ '75100'. SET MODVOL=00X1
IF SCATCD EQ '75100'. SET SEVVOL=00X1
IF STFLAG EQ '1'. SET SEVVOL=00X0
IF STFLAG EQ '1'. SET MODVOL=00X0
IF STFLAG EQ '3'. SET SEVVOL=00X1
IF STFLAG EQ '3'. SET MODVOL=00X1
IF SCATCD EQ '75099'. SET MODVOL=00X0
IF SCATCD EQ '75099'. SET SEVVOL=00X0
FUNCTION INLCD
CREATE
LOAD
PROC
FUNCTION UPDATE
REGRAD
RCRDOS=04
FINDNO=10
PARTIY=7710000000
      FUNCTION REFGEN
GROUP=1.IF SCATCD EQ '75100'.
SORT=SGECPO/A$SLOCIR/A
GROUP=2.IF SCATCD EQ '75099'.
SORT=SGECPO/A$SLOCIR/A
GROUP=3.IF SCATCD EQ '75200'.
SORT=SGECPO/A$SLOCIR/A
=      FILE     07.V6R
=      FILE     08.V7B
=      TAPE9    10.F70..25408...[illegible]
=      FILE     11.V1R
=      FILE     12.V2R.1FCH
=      FILE     13.V3R.2FCL
=      FILE     14.V4R
=      PRAPE    15/E90.R.3.BOOOIOP00/[illegible]
=      FILE     16.W1R.2R
=      FILE     20.T30
=      TAPE     28.G10..10[illegible]
```

APPENDIX B

CASUALTY CALCULATIONS

This appendix supplements the material in Section 3.3. It describes the steps required to compute casualties in the SIDAC post-processor.

The first step is to compute the proportions of the population at risk which become prompt fatalities, prompt injuries, fallout fatalities, and fallout injuries.

By assumption, the proportion of prompt fatalities (PFAT) equals the probability of severe damage = 1-SPROBS, where SPROBS is provided in the Answer File. Similarly, the proportion of prompt casualties (PCAS) (i.e., fatalities and injuries) equals the probability of moderate damage = 1-MPROBS. Therefore, proportion of injuries = PCAS-PFAT. (SPROBS and MPROS were previously defined in Section 3.3.1).

The fallout casualty calculations are more complicated. For each of the 7 day, 30 day, and 180 day time periods, a "mid-lethal dose" (MLD) and a "mid-casualty dose" (MCD) are provided. (Here casualty refers to injuries alone). Associated with these main doses are their standard deviations, "standard deviation for lethality" (SDL) and "standard deviation for casualty" (SDC), respectively. For further information on radiation doses, see (6).

Recall that MAXDOS is the maximum biological dose which would be received in a given environment if no protection existed (PF=1). To scale MAXDOS appropriately, we use that shielding value (SHLVAL) such that MAXDOS x SHLVAL = actual dose received by a sheltered individual. This shielding factor is merely the reciprocal of the effective protection factor. For each data record, there are seven values of SHLVAL, one for each PF as shown in Table 3-5. The percentage of people corresponding to a given PF is SHLPCT.

Mathematically, we define

$$\text{SHLVAL} = \frac{\text{DRM(1)/PF1} + \text{DRM(2)} \times (\text{XMULT(1)/PF1} + \text{XMULT(2)/PF2})}{\text{DRM(1)} + \text{DRM(2)}}$$

where

$DRM(1) = 1.0 - ITT^{-0.2}$

$DRM(2) = ITT^{-0.2} - JTT^{-0.2}$

PF1 = shelter protection factor

PF2 = outside protection factor (assumed equal to 1/.65)

XMULT(1) = proportion of time from ITT to JTT spent inside shelter, and

XMULT(2) = 1-XMULT(1) = proportion of time from ITT to JTT spend outside shelter

(See Section 3.3.2, for discussion of ITT and JTT.)
Further details on these quantities may be found in the Appendix of (4).

As stated above DOSE = MAXDOS x SHLVAL is the actual maximum dose received by an individual in the given fallout field and shelter. We must now determine what proportion of the population at risk this dose kills or injures. This is accomplished using the normal probability distribution.

Denote by $\Phi(x)$ the cumulative normal probability at x. Let I be the index counting the seven possible PFs as shown in Table 3-5. Then the proportion of fatalities caused by the radiation dose DOSE(I) is

$$FAT = \sum_{I=1}^{7} SHLPCT(I) \times \Phi\left(\frac{DOSE(I) - MLD}{SDL}\right)$$

where

MLD = mid-lethal dose and SDL is its standard deviation.

Similarly, the proportion of injuries caused by DOSE(I) is

$$CAS = \sum_{I=1}^{7} SHLPCT(I) \times \Phi \left(\frac{DOSE(I) - MCD}{SDC} \right)$$

where

MCD = mid-casualty dose, and SDC is its standard deviations.

Note that MLD, MCD, SDL, and SDC are different for each time period (7 day, 30 day, or 180 day). Thus, this whole calculation is repeated three times.

We now have the four casuality proportions PFAT, PCAS, FAT, and CAS. The total population at risk (capacity of the shelter) is CAP. Following steps 3-7 as outlined in Section 3.3.4, we calculate actual casualties as follows:

NPF = Number prompt fatalities = PFAT x CAP

NFF = Number fallout fatalities = FAT x (1-PFAT) x CAP

NPI = Number prompt injuries = (PCAS-PFAT) x (1-FAT) x CAP

NFI = Number fallout injuries = (1-PCAS) x (1-FAT) x CAS x CAP

NHP = Number healthy population = CAP-(NPF+NFF+NPI+NFI)

This completes the computation for one data record. We repeat this entire procedure for each data record and sum the results.

To illustrate this procedure, consider the following example. Let MPROBS = .5 and SPROBS = .7. This means that probability of moderate damage = PCAS = .5, and probability of severe damage = PFAT = .3. Let CAP = 1000, MAXDOS = 4000. Assume that for the time period in question,

MLD = 500 MCD = 200

SDL = 200 SDC = 50.

For simplicity, assume the following shelter distribution:

PF	PERCENT
200	20
50	50
10	30

We compute casualties resulting from a 3 day stay time followed by 18 days of 2/3 sheltering.

First, we compute three values of SHLVAL, one for each PF. ITT = end of period of 100% sheltering = 3 days = 72 hours. JTT = end of partial sheltering = 21 days = 504 hours.

$$\begin{aligned}
DRM(1) &= 1 - ITT^{-0.2} = .575 \\
DRM(2) &= ITT^{-0.2} - JTT^{-0.2} = .137 \\
PF1 &= 200,\ 50,\ \text{and } 10,\ \text{respectively} \\
PF1 &= 1/.65 = 1.538 \\
XMVLT(1) &= 2/3 = .667 \\
XMVLT(2) &= 1/3 = .333
\end{aligned}$$

Therefore, for PF1 = 200,

$$\begin{aligned}
SHLVAL(1) &= \frac{.575/200 + .137(.667/200 + .333/1.538)}{.575 + .137} \\
&= .046
\end{aligned}$$

Similarly, for PF1 = 50, SHLVAL(2) = .058, and for PF1 = 10, SHLVAL(3) = .135.

We now compute FAT and CAS by filling in Table B-1. By summing the two indicated columns, we find FAT = .23 and CAS = .74, i.e., 23% of the at risk population are fatalities and 74% are casualities. From before, we had PFAT = .30 and PCAS = .50. We now compute

NPF = .30 x 1000 = 300 prompt fatalities

NFF = .23 x .70x1000 = 161 fallout fatalities

NPI = (.50 - .30) x (1 - .23) x 1000 = 154 prompt injuries

NFI = (1 - .50) x (1 - .23) x .74 x 1000 = 285 fallout injuries

NNHP = 1000 - (300 + 161 + 154 + 285) = 100 uninjured people.

This data record has been completed; we would now get another record, compute the same quantities, and add them to these results.

Table B-1. Fallout casualty calculations.

PF	SHLPCT	SHLVAL	DOSE = SHLVAL x MAXDOS	$\frac{\text{DOSE-MLD}}{\text{SDL}}$	Φ_{Fatal}	SHLPCT x Φ_{Fatal}	$\frac{\text{DOSE-MCD}}{\text{SDC}}$	Φ_{Cas}	SHLPT x Φ_{Cas}
200	.20	.046	184	-1.58	.057	.0114	- .32	.374	.0748
50	.50	.058	232	-1.34	.090	.0450	.64	.739	.3695
10	.30	.135	540	.20	.579	.1737	6.8	1.000	.3000
						FAT = .2301			CAS = .7443

Assumptions:

MAXDOS = 4000

MLD = 500 MCD = 200

SDL = 200 SDC = 50

This table illustrates the calculations used to compute fatality and casualty proportions. The first four columns apply to the entire population, the next three show the fatality calculations, and the last three show the casualty calculations.

Legend:

PF = Protection factor

SHLPCT = Shelter percentage

SHLVAL = Shielding Value

MLD = Mid-lethal dose

SDL = Standard deviation of MLD

MCD = Mid-casualty dose

SDC = Standard deviation of MCD

Φ = Cumulative normal

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APPENDIX C
THE ORIGINAL SIDAC POST-PROCESSOR

Table C-1 contains a listing of the original SIDAC post-processor as written by the Command and Control Technical Center. What follows, while not a complete documentation, is intended to serve as a guide to the program segments.

LINE NUMBERS IN TABLE C-1	FUNCTION
1 - 30	Initialization
31 - 72	Initial data acquisition, continued initialization
73 -103	Read a record and assign values to variables
105 -119	Default values for PFs and percentages -- urban population
120 -134	Default values for PFs and percentages -- rural population
135 -170	Additional initialization and error calls
171 -238	The bulk of the computations -- see further comments below
239 -342(end)	Output and bookkeeping routines.

As noted above, lines 171-238 comprise the bulk of the computations. To aid in comprehension, some of the key variable one identified here. The actual flow of the computations is fairly clear.

There are many do-loops which run from 1 to 7. (See lines 171, 184, 187, 190, etc.) . These index the seven different PFs per environment. Do-loops from 1 to 3 index the three different assessment times, 7 days, 30 days, and 180 days. PR1 is the inside protection factor; PR2 is the outside

protection factor; set equal to 1/.65. The proportion of partial sheltering spent indoors, denoted XMULT(1), is equal to 1-XMULT (2). ITT is time at end of complete sheltering; JTT is time at end of partial sheltering and marks beginning of evacuation. DRM(1) and DRM(2) are dose rate multipliers for each time period. SHLVAL is the reciprocal of the effective protection factor.

SMLD (I), SIGL(I), SMLD(I), and SIGC(I) are mid-lethal dose, its standard deviation, the mid-casualty dose, and its standard deviation, respectively, for the assessment time indexed by I =1, 2, or 3. The actual values they assume (in lines 224-231 and lines 15-18) are from reference (6). (MAXDOS) x (SHLVAL) is the actual dose received. CUMN is a subroutine which computes the cumulative normal distribution. FAT and CAS store the percentage of fatalities and casualties, respectively. In lines 240-246, these percentages are converted to actual population counts.

To run this program, the Answer File must be available as device number 25. Device 5 is the card reader, so all reads to device 5 must find the data located after the source code.

Table C-1. The original SIDAC post-processor.

```
      DIMENSION IPROF(2,5,7),ISHPCT(5,7),IMULT(2,5),ISHLV(7),
     $ISHLP(7),DRM(2),ITX(4),IPCTF(5)
      DIMENSION  XMULT(2,5)
      CHARACTER ICC*2(5)
      CHARACTER TITLE1*20,TITLE2*20,TITLE3*20,TITLE4*3
      CHARACTER JNAM*5,TOPOS*8,SPAC1*4,SPAC2*3
      CHARACTER ISUB*1,SVSUB*1
      DIMENSION ALIN(3,6,3),PCT(7),ATEM(6,3),IFAT(3),ICAS(3),FAT(3),
     $ CAS(3),COM(38)
      CHARACTER         IRG*1          ,SVRG*1,ITIME*3(3),INAM*5(2),ICAT*1
      CHARACTER ICTY*2/'  '/,SVCTY*2/'  '/
      DATA ITX /24,72,240,720/
      DATA ITIME/'  7',' 30','180'/
      DIMENSION SHLVAL(16),SHLPCT(16),SMLD(3),SMCD(3),SIGL(3),SIGC(3)
      DATA SMLD/1000.,0.,450./
      DATA SMCD/200.,215.,400./
      DATA SIGL/200.,1.,135./
      DATA SIGC/60.,64.5,120./
      DATA SHLVAL/.01,.075,.15,.2,.3,.35,.7,
     $.1,.15,.2,.25,.3,.4,.55,.6,.7/
      DATA SHLPCT/.05,.12,.045,.385,.09,.21,.1,
     $.007,.0035,.036,.0105,.065,.075,.253,.25,.3/
      DIMENSION XSHLV(8),KSHLP(400)
      CHARACTER KCTY*2(50)
      DATA XSHLV/200.,100.,50.,20.,10.,5.,3.,1.4/
      DATA ISHLV/200,100,50,20,10,5,3/
      REAL MPROBS
      IPAC=0
      REWIND 25
      REWIND 10
      I=1
      KCTY(I)="  "
 1011 READ(10,1012,END=1013)KCTY(I),(KSHLP(8*(I-1)+J),J=1,8)
 1012 FORMAT(A2,8I2)
      I=I+1
      GO TO 1011
 1013 CONTINUE
      READ (5,100) TITLE1,TITLE2,TITLE3,TITLE4
 100  FORMAT (3A20,A3)
      READ (5,449,END=2121) ITT,JTT
 449  FORMAT (I4,I4)
      IF(JTT.EQ.0)JTT=504
      IF(JTT.GE.ITT)GO TO 3131
      KTT=JTT
      JTT=ITT
      ITT=KTT
 3131 CONTINUE
      DO 46 J=1,5
      READ (5,30,END=46)      ICC(J),IMULT(1,J),IMULT(2,J),
     $                        (IPROF(1,J,K),K=1,7),(IPROF(2,J,K),K=1,7),
     $(ISHPCT(J,K),K=1,7),IPCTF(J)
 30   FORMAT(    A2,2I3,14I3,7I2,I1)
 46   CONTINUE
 2121   CONTINUE
      ISUB=1H
      SVSUB=1H
```

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Table C-1. The original SIDAC post-processor (continued).

```
      MIL=1000000.
      JNAM='URBAN'
      SPAC1=4H
      SPAC2=3H
      SVCTY=2H
      SVRG=1H
      TOPOS=8H
      IEOF=0
      ILIN=60
      IFLAG=0
      DO 21 I1=1,3
      DO 21 I2=1,6
      DO 21 I3=1,3
      ALIN(I1,I2,I3)=0.
      ATEM(I2,I3)=0.
21    CONTINUE
6     READ (25,END=98) COM
      NPROBS=COM(4)
      SPROBS=COM(5)
      CALL BYTE(COM,163,ICAP,1,6)
      CALL BYTE(COM,183,IRG,1,1)
      CALL BYTE(COM,181,ICTY,1,2)
      CALL BYTE(COM,189,ISUB,1,1)
      CALL BYTE(COM,171,IFAT(1),5,2)
      CALL BYTE(COM,175,IFAT(2),5,2)
      CALL BYTE(COM,179,IFAT(3),5,2)
      CALL BYTE(COM,169,ICAS(1),5,2)
      CALL BYTE(COM,173,ICAS(2),5,2)
      CALL BYTE(COM,177,ICAS(3),5,2)
      CALL BYTE(COM,184,ICAT,1,5)
      CALL BYTE(COM,043,MAXDOS,1,6)
      CALL BYTE(COM,037,IDMDOS,1,6)
      CALL BYTE(COM,193,ISHLV(1),4,3)
      CALL BYTE(COM,196,ISHLV(2),4,3)
      CALL BYTE(COM,199,ISHLV(3),4,3)
      CALL BYTE(COM,202,ISHLV(4),4,3)
      CALL BYTE(COM,205,ISHLV(5),4,3)
      CALL BYTE(COM,208,ISHLV(6),4,3)
      CALL BYTE(COM,223,ISHLV(7),4,3)
      CALL BYTE(COM,191,ISHLP(1),5,2)
      CALL BYTE(COM,211,ISHLP(2),5,2)
      CALL BYTE(COM,213,ISHLP(3),5,2)
      CALL BYTE(COM,215,ISHLP(4),5,2)
      CALL BYTE(COM,217,ISHLP(5),5,2)
      CALL BYTE(COM,219,ISHLP(6),5,2)
      CALL BYTE(COM,221,ISHLP(7),5,2)
      IF(ICAT.EQ."75099".OR.ICAT.EQ."750990")GO TO 251
      ISHLV(1)=800
      ISHLV(2)=250
      ISHLV(3)=150
      ISHLV(4)=100
      ISHLV(5)=40
      ISHLV(6)=20
      ISHLV(7)=10
      ISHLP(1)=14
      ISHLP(2)=7
```

Table C-1. The original SIDAC post-processor (continued).

```
      ISHLP(3)=7
      ISHLP(4)=14
      ISHLP(5)=28
      ISHLP(6)=17
      ISHLP(7)=13
      GO TO 252
251   ISHLV(1)=40
      ISHLV(2)=35
      ISHLV(3)=30
      ISHLV(4)=25
      ISHLV(5)=20
      ISHLV(6)=15
      ISHLV(7)=10
      ISHLP(1)=2
      ISHLP(2)=5
      ISHLP(3)=15
      ISHLP(4)=8
      ISHLP(5)=22
      ISHLP(6)=6
      ISHLP(7)=42
252   CONTINUE
      IF(ICTY.EQ."US")GO TO 1017
      DO 1014 JJ=1,50
      IF(KCTY(JJ).EQ."  ")GO TO 1017
1014  IF(ICTY.EQ.KCTY(JJ))GO TO 1015
1015  DO 1016 KK=1,7
      ISHLV(KK)=XSHLV(KK)
1016  ISHLP(KK)=KSHLP((JJ-1)*8+KK)
1017  CONTINUE
      IF (IFLAG.EQ.1) GO TO 52
      SVCTY=ICTY
      SVRG=IRG
      SVSUB=ISUB
52    CONTINUE
      CAP=FLOAT(ICAP)
      IF(ICAT.EQ."75100".OR.ICAT.EQ."751000")CAP=CAP*1000.
      IF(ICAT.EQ."75099".OR.ICAT.EQ."750990")CAP=CAP*100.
      DO 23 J=1,3
      FAT(J)=IFAT(J)*.01
      CAS(J)=ICAS(J)*.01
23    CONTINUE
      INT=1
      INF=7
      IF (IPAC.EQ.5) INT=8
      IF (IPAC.EQ.5) INF=15
      DO 191 I3=1,3
      CAS(I3)=0.
      FAT(I3)=0.
191   CONTINUE
      II=1
44    IF(II.EQ.6) GO TO 201
      IF(ICC(II).EQ.ICTY.OR.ICC(II).EQ.'XX')     GO TO 146
      II=II+1
      GO TO 44
201   PRINT 202
202   FORMAT (15X,//////,'CARD XX MISSING')
```

Table C-1. The original SIDAC post-processor (continued).

```
      CALL EXIT
  146 DO 143 LL=1,7
  143 SHLPCT(LL)=FLOAT(ISHLP(LL))/100.
C *** THE CALCULATION USES ONLY THE PCT DIST.IN THE DATA RECORD.HOWEVER
C *** ISHPCT HAS BEEN READ IN AND PGM CAN BE MODIFIED
C *** IT IS ASSUMED THAT THERE WILL BE ONLY ONE PCT DIST. FOR BOTH
C *** (POSSIBLE) SETS OF PROTECTION FACTORS(IPROF).
C *** THE FORM OF THE CALCULATION ASSUMED FOR THE SECOND TIME PERIOD
C *** IS 1ST MULT*(1./1ST PROT. FACT.) + 2ND MULT*(1./2ND P.F.).
C *** ALSO IT IS ASSUMED THAT 1ST PERIOD USES THE PROT. FACT. IN THE
C *** DATA BASE RECORD.
C ***
C *** IPCTF IS THE FLAG TO USE NEW PCT DIST. OR NOT.
      IF(IPCTF(II).EQ.0) GO TO 144
      DO 145 LL=1,7
  145 SHLPCT(LL)=FLOAT(ISHPCT(II,LL))/100.
  144 IF(II.LT.6) GO TO 147
      DO 148 JJ=1,7
  148 SHLVAL(JJ)=FLOAT(ISHLV(JJ))/100.
      GO TO 991
  147 DO 149 K=1,7
      PR1=FLOAT(IPROF(1,II,K))
      PR2=FLOAT(IPROF(2,II,K))
      IF(IPROF(1,II,K).LE.0) PR1=FLOAT(ISHLV(K))
      IF(IPROF(2,II,K).LE.0) PR2=FLOAT(ISHLV(K))
C *** IF THE PROTECTION FACTOR IN THE DATA BASE RECORD AND THEPROT.
C *** FACT. IN THE CHANGE CARD ARE BOTH 0, IT IS ASSUMED THAT THE
C *** PROT. FACT. = 1./.65
      IF(IPROF(1,II,K).LE.0.AND.ISHLV(K).LE.0) PR1=1./.65
      IF(IPROF(2,II,K).LE.0.AND.ISHLV(K).LE.0) PR2=1./.65
      IF(IPROF(1,II,K).EQ. 1) PR1=1./.65
      IF(IPROF(2,II,K).EQ. 1) PR2=1./.65
      IF(DRM(1)+DRM(2).LE.0) SHLVAL(K)=.65
      XMULT(1,II)=FLOAT(IMULT(1,II))/100.
      XMULT(2,II)=FLOAT(IMULT(2,II))/100.
      IF(IMULT(1,II).EQ.0.AND.IMULT(2,II).EQ.0) XMULT(1,II)=1.0
      DRM(1)=1-ITT**(-.2)
      DRM(2)=ITT**(-.2)-JTT**(-.2)
      IF((ICTY.EQ."JA".OR.ICTY.EQ."TW").AND.K.EQ.1)PR1=1.4
      IF(ICTY.EQ."TW".AND.K.EQ.1)SHLPCT(1)=.3
      IF(ICTY.EQ."JA".AND.K.EQ.1)SHLPCT(1)=.4
      FAC1=DRM(1)*(1./PR1)
      FAC2=XMULT(1,II)*(1./PR1)
      FAC3=XMULT(2,II)*(1./PR2)
      FAC4=DRM(2)          *(FAC2+FAC3)
      FAC5=DRM(1)+DRM(2)
      FAC6=FAC1+FAC4
      SHLVAL(K)=FAC6/FAC5
  149 CONTINUE
  991 CONTINUE
      INT=1
      INF=7
      DO 999 I1=1,3
      DO 999 I2=INT,INF
      SMLD(2)=1000.
      SIGL(2)=200.
```

Table C-1. The original SIDAC post-processor (continued).

```
          IF(MAXDOS*SHLVAL(I2).LE.400.)SMLD(2)=540.
          IF(MAXDOS*SHLVAL(I2).LE.400.)SIGL(2)=162.
          IF(MAXDOS*SHLVAL(I2).GT.400..AND.MAXDOS*SHLVAL(I2).LE.1300.)
         $   SMLD(2)=720.
          IF(MAXDOS*SHLVAL(I2).GT.400..AND.MAXDOS*SHLVAL(I2).LE.1300.)
         $   SIGL(2)=370.
          FAT(I1)=FAT(I1)+CUMN((MAXDOS*SHLVAL(I2)-SMLD(I1))/SIGL(I1))
         $*SHLPCT(I2)
          CAS(I1)=CAS(I1)+CUMN((MAXDOS*SHLVAL(I2)-SMCD(I1))/SIGC(I1))
         $*SHLPCT(I2)
          IF((MAXDOS*SHLVAL(I2)).EQ.0) FAT(I1)=0.
          IF((MAXDOS*SHLVAL(I2)).EQ.0) CAS(I1)=0.
  999     CONTINUE
          DO 22 I=1,3
          ATEM(6,I)=CAP
          ATEM(5,I)=(1.0-SPROBS)*CAP
          ATEM(1,I)=SPROBS*CAP*FAT(I)
          ATEM(2,I)=(SPROBS-MPROBS)*(1.0-FAT(I))*CAP
          ATEM(3,I)=MPROBS*(1.0-FAT(I))*CAS(I)*CAP
          ATEM(4,I)=CAP-(ATEM(5,I)+ATEM(1,I)+ATEM(2,I)+ATEM(3,I))
          IF (ATEM(4,I).LT.0.) ATEM(4,I)=0.
   22     CONTINUE
          IF (IFLAG.EQ.0) GO TO 4
          IF (ICTY.NE.SVCTY.OR.IRG.NE.SVRG.OR.ISUB.NE.SVSUB) I1=1
          IF (ICTY.NE.SVCTY.OR.IRG.NE.SVRG.OR.ISUB.NE.SVSUB) GO TO 7
    4     IFLAG=1
          DO 5 J1=1,3
          DO 5 J2=1,6
          DO 5 J3=1,3
          ALIN(J1,J2,J3)=ALIN(J1,J2,J3)+ATEM(J2,J3)
    5     CONTINUE
          IF (IEOF.EQ.1) GO TO 7
          GO TO 6
    7     ILIN=ILIN+4
          IF (ILIN.LE.53) GO TO 3
   33     PRINT 69
   69     FORMAT (1H1)
          PRINT 61
          PRINT 62,TITLE1
          PRINT 63,TITLE2,JNAM
          PRINT 64, TITLE3
          PRINT 65,TITLE4
          PRINT 76
          PRINT 68
          PRINT 66
   61     FORMAT (T2,'** RED ON BLUE',40X,'POPULATION ASSESSMENT')
   62     FORMAT (T2,'** CASE/SCENARIO: ',A20)
   63     FORMAT (T2,'** SPEC INSTR: ',A20,26X,A5)
   64     FORMAT (T2,'** SPEC INSTR: ',A20,26X,5(1H-))
   65     FORMAT (T2,'**',1X,A3,1X,'ASSESSMENT')
   68     FORMAT (T37,'FATALITIES',36X,'INJURIES')
   66     FORMAT( T22,43(1H-),2X,43(1H-),6X,'RESIDUAL',3X,'ASSESS',/,
         $ 12X,'TOT POP',6X,2('PROMPT',8X,'FALLOUT',10X,'TOTAL',9X),
         $ 2X,'POP',7X,'TIME',/,12X,7(1H-),2X,7(13(1H-),2X),6(1H-),/,
         $ 1X,'REG',2X,'CTRY',4X,'MIL',7X,6('MIL',3X,'PCT',6X),
         $ 'MIL',3X,'PCT',4X,'DAYS',/,1X,3(1H-),2X,4(1H-),3X,5(1H-),3X,
```

Table C-1. The original SIDAC post-processor (continued).

```
     $ 7(8(1H-),1X,4(1H-),2X),6(1H-),//)
      ILIN=17
    8 DO 13 K2=1,6
      DO 13 K3=1,3
      ALIN(I1,K2,K3)=ALIN(I1,K2,K3)/MIL
   13 CONTINUE
      GO TO (40,41,42),I1
   40 ENCODE(TOPOS,50) SVRG,SPAC1,SVCTY
   50 FORMAT (A1,A4,A2,' ')
      GO TO 75
   41 ENCODE (TOPOS,51) SVRG,SPAC2
   51 FORMAT (A1,A3,'ALL ')
      GO TO 75
   42 ENCODE (TOPOS,57)
   57 FORMAT ('WW',2X,'ALL')
   75 DO 9 I3=1,3
      TFA=ALIN(I1,5,I3)+ALIN(I1,1,I3)
      TIN=ALIN(I1,2,I3)+ALIN(I1,3,I3)
      DO 10 K=1,5
      PCT(K)=(ALIN(I1,K,I3)/ALIN(I1,6,I3))*100.
   10 CONTINUE
      PCT(6)=(TFA/ALIN(I1,6,I3))*100.
      PCT(7)=(TIN/ALIN(I1,6,I3))*100.
      PRINT 1, TOPOS     ,ALIN(I1,6,I3),ALIN(I1,5,I3),PCT(5),
     $ ALIN(I1,1,I3),PCT(1),TFA,PCT(6),ALIN(I1,2,I3),PCT(2),
     $ ALIN(I1,3,I3),PCT(3),TIN,PCT(7),ALIN(I1,4,I3),PCT(4),ITIME(I3)
    1 FORMAT (2X,A8,      1X,F8.3,2X,7(F8.3,1X,F4.1,2X),1X,A3)
    9 CONTINUE
      IF (I1.EQ.2) PRINT 76
      IF (I1.EQ.2) ILIN=ILIN+1
      PRINT 76
   76 FORMAT (/)
      DO 11 I2=1,6
      DO 11 I3=1,3
      ALIN(I1,I2,I3)=0.0
   11 CONTINUE
      IF (I1.EQ.1) SVCTY=ICTY
      IF (I1.EQ.3.AND.IEOF.EQ.1) GO TO 99
      IF (I1.EQ.2) SVRG=IRG
      IF (I1.EQ.2) GO TO 12
      IF (I1.EQ.3) SVSUB=ISUB
      IF (I1.EQ.3) ILIN=60
      IF (I1.EQ.3) JNAM ='RURAL'
      IF (I1.EQ.3) GO TO 4
      IF (IRG.NE.SVRG.OR.ISUB.NE.SVSUB.OR.IEOF.EQ.1) I1=2
      IF (IRG.NE.SVRG.OR.ISUB.NE.SVSUB.OR.IEOF.EQ.1) GO TO 7
      GO TO 4
   12 IF (ISUB.NE.SVSUB.OR.IEOF.EQ.1) I1=3
      IF (ISUB.NE.SVSUB.OR.IEOF.EQ.1) GO TO 7
      GO TO 4
   98 IEOF=1
      I1=1
      GO TO 7
   99 STOP
      END
```

APPENDIX D
THE MODIFIED SIDAC POST-PROCESSOR

Table D-1 presents the SIDAC post-processor as modified to handle the Attrition Rate equations. It is slightly longer than the original (361 lines to 342 lines). Other than some overall modifications and simplifications (which could be equally well applied to the orginal) the major changes occur in the prime computational section, lines 171 to 252, and at line 32. (Other changes, such as various initializations, will become obvious upon comparing the two sets of code).

Line 32 reads the two coefficients from the attrition rate equation, y = AA x t + BB. On lines 171 to 252, the primary modification is the addition of two loops (line 206 and 238) indexed from 1 to N1, where N1 is the number of time periods (including the "Zeroth") until the entire population has left the shelter. All fatalities and casualties are calculated separately for each time period, and a separate SHLVAL, denoted SHVALX, is computed for each. The dose received for each group is held in STOR. FATX and CASX contain separate casualty percentages for each group. These separate figures are finally recombined in lines 254-263 by multiplying by the proportion of people in each group. The remainder of the program is identical to the orginial.

To run this program, follow the same procedure as in the original post-processor, except a card giving the values of AA and BB must be included to be read at line 32.

Table D-1. The modified SIDAC post-processor.

```
      DIMENSION IPROF(2,5,7),ISHPCT(5,7),IMULT(2,5),ISHLV(7),
     &ISHLP(7),DR1(2),ITX(4),IPCTF(5)
      DIMENSION  XMULT(2,5)
      CHARACTER ICC*2(5)
      CHARACTER TITLE1*20,TITLE2*20,TITLE3*20,TITLE4*3
      CHARACTER JNAM*5,TOPOS*6,SPAC1*4,SPAC2*3
      CHARACTER ISUB*1,SVSUB*1
      DIMENSION ALIM(3,6,3),PCT(7),ATEM(5,3),IFAT(3),ICAS(3),FAT(3),
     & CAS(3),COM(36)
      CHARACTER        IRG*1          ,SVRG*1,ITIME*3(3),INAM*5(2),ICAT*1
      CHARACTER ICTY*2/'  '/,SVCTY*2/'  '/
      DATA ITX /24,72,240,720/
      DATA ITIME/'  7',' 30','180'/
      DIMENSION SHLVAL(16),SHLPCT(16),SMLD(3),SMCD(3),SIGL(3),SIGC(3)
      DATA SMLD/1000.,0.,450./
      DATA SMCD/200.,215.,400./
      DATA SIGL/200.,1.,135./
      DATA SIGC/50.,64.5,120./
      DATA SHLVAL/.01,.075,.15,.2,.3,.05,.7,
     &.1,.15,.2,.25,.3,.4,.55,.6,.7/
      DATA SHLPCT/.05,.12,.045,.365,.09,.21,.1,
     &.007,.0035,.036,.0105,.065,.075,.253,.25,.3/
      DIMENSION XSHLV(8),KSHLP(400)
      CHARACTER KCTY*2(50)
      DATA XSHLV/200.,100.,50.,20.,10.,5.,3.,1.4/
      DATA ISHLV/200,100,50,20,10,5,3/
      REAL MPROBS
      IPAC=0
      REWIND 25
      REWIND 10
      DIMENSION SHVALX(16,50),FATA(3,50),CASX(3,50)
       READ(47,776) AA,BB
 776   FORMAT(2F10.6)
      I=1
      KCTY(I)="  "
 1011 READ(10,1012,END=1013)KCTY(I),(KSHLP(8*(I-1)+J),J=1,8)
 1012 FORMAT(A2,8I2)
      I=I+1
      GO TO 1011
 1013 CONTINUE
      READ (5,100) TITLE1,TITLE2,TITLE3,TITLE4
 100  FORMAT (3A20,A3)
      READ (5,449,END=2121) ITT,JTT
 449  FORMAT (I4,I4)
      IF(JTT.EQ.0)JTT=504
      IF(JTT.GE.ITT)GO TO 3131
      KTT=JTT
      JTT=ITT
      ITT=KTT
 3131 CONTINUE
      DO 46 J=1,5
      READ (5,30,END=46)      ICC(J),IMULT(1,J),IMULT(2,J),
     &                        (IPROF(1,J,K),K=1,7),(IPROF(2,J,K),K=1,7),
     &(ISHPCT(J,K),K=1,7),IPCTF(J)
 30   FORMAT(   A2,2I3,14I3,7I2,I1)
 46   CONTINUE
```

Table D-1. The modified SIDAC post-processor (continued).

```
 2121   CONTINUE
      ISUB=1H
      SVSUB=1H
      MIL=1000000.
      JNAM='URBAN'
      SPAC1=4H
      SPAC2=3H
      SVCTY=2H
      SVRG=1H
      TOPOS=8H
      IEOF=0
      ILIN=60
      IFLAG=0
      DO 21 I1=1,3
      DO 21 I2=1,6
      DO 21 I3=1,3
      ALIN(I1,I2,I3)=0.
      ATEM(I2,I3)=0.
 21   CONTINUE
 6    READ (25,END=98) COM
      MPROBS=COM(4)
      SPROBS=COM(5)
      CALL BYTE(COM,163,ICAP,1,6)
      CALL BYTE(COM,133,IRG,1,1)
      CALL BYTE(COM,161,ICTY,1,2)
      CALL BYTE(COM,169,ISUB,1,1)
      CALL BYTE(COM,171,IFAT(1),5,2)
      CALL BYTE(COM,175,IFAT(2),5,2)
      CALL BYTE(COM,179,IFAT(3),5,2)
      CALL BYTE(COM,169,ICAS(1),5,2)
      CALL BYTE(COM,173,ICAS(2),5,2)
      CALL BYTE(COM,177,ICAS(3),5,2)
      CALL BYTE(COM,184,ICAT,1,5)
      CALL BYTE(COM,043,MAXDOS,1,6)
      CALL BYTE(COM,037,IDNDOS,1,6)
      CALL BYTE(COM,193,ISHLV(1),4,3)
      CALL BYTE(COM,196,ISHLV(2),4,3)
      CALL BYTE(COM,199,ISHLV(3),4,3)
      CALL BYTE(COM,202,ISHLV(4),4,3)
      CALL BYTE(COM,205,ISHLV(5),4,3)
      CALL BYTE(COM,208,ISHLV(6),4,3)
      CALL BYTE(COM,223,ISHLV(7),4,3)
      CALL BYTE(COM,191,ISHLP(1),5,2)
      CALL BYTE(COM,211,ISHLP(2),5,2)
      CALL BYTE(COM,213,ISHLP(3),5,2)
      CALL BYTE(COM,215,ISHLP(4),5,2)
      CALL BYTE(COM,217,ISHLP(5),5,2)
      CALL BYTE(COM,219,ISHLP(6),5,2)
      CALL BYTE(COM,221,ISHLP(7),5,2)
      IF(ICAT.EQ."75099".OR.ICAT.EQ."750990")GO TO 251
      ISHLV(1)=800
      ISHLV(2)=250
      ISHLV(3)=150
      ISHLV(4)=100
      ISHLV(5)=40
      ISHLV(6)=20
```

Table D-1. The modified SIDAC post-processor (continued).

```
      ISHLV(7)=10
      ISHLP(1)=14
      ISHLP(2)=7
      ISHLP(3)=7
      ISHLP(4)=14
      ISHLP(5)=28
      ISHLP(6)=17
      ISHLP(7)=13
      GO TO 252
251   ISHLV(1)=40
      ISHLV(2)=35
      ISHLV(3)=30
      ISHLV(4)=25
      ISHLV(5)=20
      ISHLV(6)=15
      ISHLV(7)=10
      ISHLP(1)=2
      ISHLP(2)=5
      ISHLP(3)=15
      ISHLP(4)=8
      ISHLP(5)=22
      ISHLP(6)=6
      ISHLP(7)=42
252   CONTINUE
      IF(ICTY.EQ."US")GO TO 1017
      DO 1014 JJ=1,50
      IF(KCTY(JJ).EQ."  ")GO TO 1017
1014  IF(ICTY.EQ.KCTY(JJ))GO TO 1015
1015  DO 1016 KK=1,7
      ISHLV(KK)=XSHLV(KK)
1016  ISHLP(KK)=KSHLP((JJ-1)*8+KK)
1017  CONTINUE
      IF (IFLAG.EQ.1) GO TO 52
      SVCTY=ICTY
      SVRG=IRG
      SVSUB=ISUB
52    CONTINUE
      CAP=FLOAT(ICAP)
      IF(ICAT.EQ."75100".OR.ICAT.EQ."751000")CAP=CAP*1000.
      IF(ICAT.EQ."75099".OR.ICAT.EQ."750990")CAP=CAP*100.
23    CONTINUE
      INT=1
      INF=7
      IF (IPAC.EQ.5) INT=6
      IF (IPAC.EQ.5) INF=10
      DO 191 I3=1,3
      CAS(I3)=0.
      FAT(I3)=0.
191   CONTINUE
      II=1
44    IF(II.EQ.6) GO TO 201
      IF(ICC(II).EQ.ICTY.OR.ICC(II).EQ.'XX')      GO TO 140
      II=II+1
      GO TO 44
201   PRINT 202
202   FORMAT (15X,//////,'CARD XX MISSING')
```

Table D-1. The modified SIDAC post-processor (continued).

```
          CALL EXIT
    146   DO 143 LL=1,7
    143   SHLPCT(LL)=FLOAT(ISHLP(LL))/100.
C ***     THE CALCULATION USES ONLY THE PCT DIST.IN THE DATA RECORD.HOWEVER
C ***     ISHPCT HAS BEEN READ IN AND PGM CAN BE MODIFIED
C ***     IT IS ASSUMED THAT THERE WILL BE ONLY ONE PCT DIST. FOR BOTH
C ***     (POSSIBLE) SETS OF PROTECTION FACTORS(IPROF).
C ***     THE FORM OF THE CALCULATION ASSUMED FOR THE SECOND TIME PERIOD
C ***     IS 1ST MULT*(1./1ST PROT. FACT.) + 2ND MULT*(1./2ND P.F.).
C ***     ALSO IT IS ASSUMED THAT 1ST PERIOD USES THE PROT. FACT. IN THE
C ***     DATA BASE RECORD.
C ***
C ***     IPCTF IS THE FLAG TO USE NEW PCT DIST. OR NOT.
          IF(IPCTF(II).EQ.0) GO TO 144
          DO 145 LL=1,7
    145   SHLPCT(LL)=FLOAT(ISHPCT(II,LL))/100.
    144   IF(II.LT.6) GO TO 147
          DO 148 JJ=1,7
    148   SHLVAL(JJ)=FLOAT(ISHLV(JJ))/100.
          GO TO 991
    147   DO 149 K=1,7
          PR1=FLOAT(IPROF(1,II,K))
          PR2=FLOAT(IPROF(2,II,K))
          IF(IPROF(1,II,K).LE.0) PR1=FLOAT(ISHLV(K))
          IF(IPROF(2,II,K).LE.0)PR2=1.53846
C ***     IF THE PROTECTION FACTOR IN THE DATA BASE RECORD AND THEPROT.
C ***     FACT. IN THE CHANGE CARD ARE BOTH 0, IT IS ASSUMED THAT THE
C ***     PROT. FACT. = 1./.65
          XMULT(1,II)=FLOAT(IMULT(1,II))/100.
          XMULT(2,II)=FLOAT(IMULT(2,II))/100.
          IF(IMULT(1,II).EQ.0.AND.IMULT(2,II).EQ.0) XMULT(1,II)=1.0
          IF((ICTY.EQ."JA".OR.ICTY.EQ."TW").AND.K.EQ.1)PR1=1.4
          IF(ICTY.EQ."TW".AND.K.EQ.1)SHLPCT(1)=.3
          IF(ICTY.EQ."JA".AND.K.EQ.1)SHLPCT(1)=.4
           ITT=-24
           N1=    ((1.0 -BB)/(AA*24.))+2
           DO 153 NA=1,N1
          DO 154 I1=1,3
          FATX(I1,NA)=0.
   154     CASX(I1,NA)=0.
           ITT=ITT+24
          IF(ITT.EQ.0)GO TO 152
          IF(ITT.GE.504)GO TO 151
          DRM(1)=1-ITT**(-.2)
          DRM(2)=ITT**(-.2)-JTT**(-.2)
          GO TO 150
   151    DRM(1)=1.-ITT**(-.2)
          DRM(2)=0.
          GO TO 150
   152     DRM(1)=1.
           DRM(2)=-JTT**(-.2)
   150    CONTINUE
          FAC1=DRM(1)*(1./PR1)
          FAC2=XMULT(1,II)*(1./PR1)
          FAC3=XMULT(2,II)*(1./PR2)
          FAC4=DRM(2)          *(FAC2+FAC3)
```

Table D-1. The modified SIDAC post-processor (continued).

```
             FAC5=DRM(1)+DRM(2)
             FAC6=FAC1+FAC4
             SHLVAL(K)=FAC6/FAC5
              SHVALX(K,NA)=SHLVAL(K)
      9563     FORMAT(1X,I10,6F10.4)
      153    CONTINUE
       149   CONTINUE
       991   CONTINUE
             INT=1
             INF=7
             DO 999 I1=1,3
             DO 999 I2=INT,INF
              DO 999 NA=1,N1
              SMLD(2)=1000.
              SIGL(2)=200.
              STOR=MAXDOS*SHVALX(I2,NA)
              IF(STOR.LE.400.)SMLD(2)=540.
              IF(STOR.LE.400.)SIGL(2)=162.
              IF(STOR.GT.400..AND.STOR.LE.1300.)SMLD(2)=720.
              IF(STOR.GT.400..AND.STOR.LE.1300.)SIGL(2)=370.
              FATX(I1,NA)=FATX(I1,NA)+CUMN((STOR-SMLD(I1))/SIGL(I1))*SHLPCT(I2)
              CASX(I1,NA)=CASX(I1,NA)+CUMN((STOR-SMCD(I1))/SIGC(I1))*SHLPCT(I2)
             IF(STOR.GT.1000.)JJJCN=JJJCN+1
              IF(STOR.NE.0)GO TO 999
              FATX(I1,NA)=0.
              CASX(I1,NA)=0.
       999   CONTINUE
             IIN1= N1-2
              DO 157 I1=1,3
              CAS(I1)=BB*CASX(I1,1)+(1.0 -(IIN1*AA*24.) -BB      )*CASX(I1,N1)
              FAT(I1)=BB*FATX(I1,1)+(1.0 -(IIN1*AA*24.) -BB      )*FATX(I1,N1)
              TEMP1=0.
              TEMP2=0.
              DO 156 NB=2,N1-1
              TEMP1=TEMP1+FATX(I1,NB)
      156     TEMP2=TEMP2+CASX(I1,NB)
              FAT(I1)=FAT(I1)+(24.*AA*TEMP1)
      157     CAS(I1)=CAS(I1)+(24.*AA*TEMP2)
             DO 22 I=1,3
             ATEM(6,I)=CAP
             ATEM(5,I)=(1.0-SPROBS)*CAP
             ATEM(1,I)=SPROBS*CAP*FAT(I)
             ATEM(2,I)=(SPROBS-MPROBS)*(1.0-FAT(I))*CAP
             ATEM(3,I)=MPROBS*(1.0-FAT(I))*CAS(I)*CAP
             ATEM(4,I)=CAP-(ATEM(5,I)+ATEM(1,I)+ATEM(2,I)+ATEM(3,I))
             IF (ATEM(4,I).LT.0.) ATEM(4,I)=0.
       22    CONTINUE
             IF (IFLAG.EQ.0) GO TO 4
             IF (ICTY.NE.SVCTY.OR.IRG.NE.SVRG.OR.ISUB.NE.SVSUB) I1=1
             IF (ICTY.NE.SVCTY.OR.IRG.NE.SVRG.OR.ISUB.NE.SVSUB) GO TO 7
       4     IFLAG=1
             DO 5 J1=1,3
             DO 5 J2=1,6
             DO 5 J3=1,3
             ALIN(J1,J2,J3)=ALIN(J1,J2,J3)+ATEM(J2,J3)
       5     CONTINUE
```

Table D-1. The modified SIDAC post-processor (continued).

```
      IF (IEOF.EQ.1) GO TO 7
      GO TO 6
 7    ILIN=ILIN+4
      IF (ILIN.LE.55) GO TO 8
 35   PRINT 69
 69   FORMAT (1H1)
      PRINT 61
      PRINT 62,TITLE1
      PRINT 63,TITLE2,JNAM
      PRINT 64, TITLE3
      PRINT 65,TITLE4
      PRINT 76
      PRINT 68
      PRINT 66
 61   FORMAT (T2,'** RED ON BLUE',40X,'POPULATION ASSESSMENT')
 62   FORMAT (T2,'** CASE/SCENARIO: ',A20)
 63   FORMAT (T2,'** SPEC INSTR: ',A20,26X,A5)
 64   FORMAT (T2,'** SPEC INSTR: ',A20,26X,5(1H-))
 65   FORMAT (T2,'**',1X,A3,1X,'ASSESSMENT')
 68   FORMAT (T37,'FATALITIES',36X,'INJURIES')
 66   FORMAT( T22,43(1H-),2X,43(1H-),6X,'RESIDUAL',3X,'ASSESS',/,
     & 12X,'TOT POP',6X,2('PROMPT',8X,'FALLOUT',10X,'TOTAL',9X),
     & 2X,'POP',7X,'TIME',/,12X,7(1H-),2X,7(13(1H-),2X),6(1H-),/,
     & 1X,'REG',2X,'CTRY',4X,'MIL',7X,6('MIL',3X,'PCT',6X),
     & 'MIL',3X,'PCT',4X,'DAYS',/,1X,3(1H-),2X,4(1H-),3X,5(1H-),3X,
     & 7(8(1H-),1X,4(1H-),2X),6(1H-),//)
      ILIN=17
 8    DO 13 K2=1,6
      DO 13 K3=1,3
      ALIN(I1,K2,K3)=ALIN(I1,K2,K3)/MIL
 13   CONTINUE
      GO TO (40,41,42),I1
 40   ENCODE(TOPOS,50) SVRG,SPAC1,SVCTY
 50   FORMAT (A1,A4,A2,' ')
      GO TO 75
 41   ENCODE (TOPOS,51) SVRG,SPAC2
 51   FORMAT (A1,A3,'ALL ')
      GO TO 75
 42   ENCODE (TOPOS,57)
 57   FORMAT ('WW',2X,'ALL')
 75   DO 9 I3=1,3
      TFA=ALIN(I1,5,I3)+ALIN(I1,1,I3)
      TIN=ALIN(I1,2,I3)+ALIN(I1,3,I3)
      DO 10 K=1,5
      PCT(K)=(ALIN(I1,K,I3)/ALIN(I1,6,I3))*100.
 10   CONTINUE
      PCT(6)=(TFA/ALIN(I1,6,I3))*100.
      PCT(7)=(TIN/ALIN(I1,6,I3))*100.
      PRINT 1, TOPOS      ,ALIN(I1,6,I3),ALIN(I1,5,I3),PCT(5),
     & ALIN(I1,1,I3),PCT(1),TFA,PCT(6),ALIN(I1,2,I3),PCT(2),
     & ALIN(I1,3,I3),PCT(3),TIN,PCT(7),ALIN(I1,4,I3),PCT(4),ITIME(I3)
 1    FORMAT (2X,A8,       1X,F8.3,2X,7(F8.3,1X,F4.1,2X),1X,A3)
 9    CONTINUE
      IF (I1.EQ.2) PRINT 76
      IF (I1.EQ.2) ILIN=ILIN+1
      PRINT 76
```

Table D-1. The modified SIDAC post-processor (continued).

```
 76   FORMAT (/)
      DO 11 I2=1,6
      DO 11 I3=1,3
      ALIN(I1,I2,I3)=0.0
 11   CONTINUE
      IF (I1.EQ.1) SVCTY=ICTY
      IF (I1.EQ.3.AND.IEOF.EQ.1) GO TO 99
      IF (I1.EQ.2) SVRG=IRG
      IF (I1.EQ.2) GO TO 12
      IF (I1.EQ.3) SVSUB=ISUB
      IF (I1.EQ.3) ILIN=60
      IF (I1.EQ.3) JNAM ='RURAL'
      IF (I1.EQ.3) GO TO 4
      IF (IRG.NE.SVRG.OR.ISUB.NE.SVSUB.OR.IEOF.EQ.1) I1=2
      IF (IRG.NE.SVRG.OR.ISUB.NE.SVSUB.OR.IEOF.EQ.1) GO TO 7
      GO TO 4
 12   IF (ISUB.NE.SVSUB.OR.IEOF.EQ.1) I1=3
      IF (ISUB.NE.SVSUB.OR.IEOF.EQ.1) GO TO 7
      GO TO 4
 98   IEOF=1
      I1=1
      GO TO 7
 99   STOP
      END
```

APPENDIX E
SIDAC POST-PROCESSOR RESULTS

Tables E-1 to E-9 present the complete results of casualty calculations for nine different stay time assumptions. The first seven are traditional stay times, ranging from 3/4 day fully sheltered, 20 1/4 day partially sheltered, to 21 days fully sheltered. The last two are the Best and Worst Cases from the Attrition Rate Model.

The column headings one for the most part self-explanatory. All population figures are in millions. The three assessment times per table are 7 days, 30 days, and 180 days, as indicated in the last column. For each table, the upper chart refers to the urban population; the lower, to the rural population.

Table E-1. SIDAC post-processor results - 3/4 day sheltered, 20 1/4 days 2/3 sheltered.

URBAN

	TOT POP	FATALITIES						INJURIES						RESIDUAL POP		ASSESS TIME
		PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL				
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	1.723	1.3	93.854	71.4	22.980	17.5	2.999	2.3	25.979	19.8	11.600	8.8	7
US	131.433	92.131	70.1	3.818	2.9	95.949	73.0	21.462	16.3	2.270	1.7	23.732	18.1	11.751	8.9	30
US	131.433	92.131	70.1	6.123	4.7	98.254	74.8	19.773	15.0	0.518	0.4	20.291	15.4	12.888	9.8	180

RURAL

	TOT POP	FATALITIES						INJURIES						RESIDUAL POP		ASSESS TIME
		PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL				
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	3.260	3.9	10.752	12.9	11.718	14.1	12.378	14.9	24.096	29.0	48.305	58.1	7
US	83.153	7.493	9.0	6.392	7.7	13.885	16.7	10.969	13.2	9.396	11.3	20.365	24.5	48.903	58.8	30
US	83.153	7.493	9.0	9.801	11.8	17.294	20.8	10.141	12.2	2.253	2.7	12.394	14.9	53.466	64.3	180

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Table E-2. SIDAC post-processor results - 2 days sheltered, 19 days 2/3 sheltered.

URBAN

	TOT POP	FATALITIES						INJURIES						RESIDUAL POP		ASSESS TIME
		PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL				
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.960	0.7	93.091	70.8	23.510	17.9	2.322	1.8	25.833	19.7	12.509	9.5	7
US	131.433	92.131	70.1	2.429	1.8	94.560	71.9	22.458	17.1	1.800	1.4	24.258	18.5	12.614	9.6	30
US	131.433	92.131	70.1	4.033	3.1	96.164	73.2	21.309	16.2	.502	0.4	21.811	16.6	13.458	10.2	180

RURAL

	TOT POP	FATALITIES						INJURIES						RESIDUAL POP		ASSESS TIME
		PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL				
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	2.125	2.6	9.618	11.6	11.976	14.4	10.738	12.9	22.714	27.3	50.821	61.1	7
US	83.153	7.493	9.0	4.743	5.7	12.236	14.7	11.352	13.7	8.234	9.9	19.587	23.6	51.331	61.7	30
US	83.153	7.493	9.0	7.587	9.1	15.080	18.1	10.664	12.8	2.081	2.5	12.745	15.3	55.321	66.5	180

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Table E-3. SIDAC post-processor results - 3 days sheltered, 18 days 2/3 sheltered.

URBAN

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.750	0.6	92.881	70.7	23.659	18.0	2.078	1.6	25.737	19.6	12.815	9.8	7
US	131.433	92.131	70.1	1.994	1.5	94.125	71.6	22.770	17.3	1.637	1.2	24.408	18.6	12.900	9.8	30
US	131.433	92.131	70.1	3.324	2.5	95.455	72.6	21.819	16.6	0.493	0.4	22.312	17.0	13.666	10.4	180

RURAL

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	1.796	2.2	9.289	11.2	12.047	14.5	10.106	12.2	22.153	26.6	51.712	62.2	7
US	83.153	7.493	9.0	4.214	5.1	11.707	14.1	11.474	13.8	7.787	9.4	19.261	23.2	52.185	62.8	30
US	83.153	7.493	9.0	6.836	8.2	14.329	17.2	10.846	13.0	2.022	2.4	12.869	15.5	55.956	67.3	180

6020 78W

Table E-4. SIDAC post-processor results - 5 days sheltered, 16 days 2/3 sheltered.

URBAN

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.533	0.4	92.664	70.5	23.809	18.1	1.763	1.3	25.572	19.5	13.197	10.0	7
US	131.433	92.131	70.1	1.522	1.2	93.653	71.3	23.105	17.6	1.416	1.1	24.521	18.7	13.260	10.1	30
US	131.433	92.131	70.1	2.567	2.0	94.698	72.1	22.358	17.0	0.454	0.3	22.812	17.4	13.923	10.6	180

RURAL

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	1.447	1.7	8.939	10.8	12.119	14.6	9.291	11.2	21.410	25.7	52.804	63.5	7
US	83.153	7.493	9.0	3.613	4.3	11.105	13.4	11.612	14.0	7.210	8.7	18.822	22.6	53.226	64.0	30
US	83.153	7.493	9.0	5.944	7.1	13.436	16.2	11.061	13.3	1.957	2.4	13.018	15.7	56.699	68.2	180

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Table E-5. SIDAC post-processor results - 7 days sheltered, 14 days 2/3 sheltered.

URBAN

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.425	0.3	92.556	70.4	23.884	18.2	1.534	1.2	25.418	19.3	13.459	10.2	7
US	131.433	92.131	70.1	1.265	1.0	93.396	71.1	23.286	17.7	1.251	1.0	24.537	18.7	13.501	10.3	30
US	131.433	92.131	70.1	2.146	1.6	94.277	71.7	22.657	17.2	0.422	0.3	23.079	17.6	14.077	10.7	180

RURAL

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	1.252	1.5	8.745	10.5	12.157	14.6	8.748	10.5	20.906	25.1	53.503	64.3	7
US	83.153	7.493	9.0	3.253	3.9	10.746	12.9	11.694	14.1	6.827	8.2	18.521	22.3	53.887	64.8	30
US	83.153	7.493	9.0	5.392	6.5	12.885	15.5	11.192	13.5	1.916	2.3	13.109	15.8	57.160	68.7	180

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DEVELOPMENT AND APPLICATION OF A MODEL OF FALLOUT SHELTER STAY --ETC(U)
DEC 78 J H KINRICH, R A LEVIT, N J MARESCA DNA001-78-C-0060
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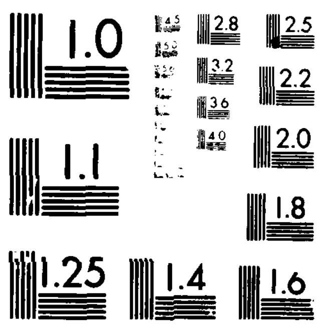

MICROCOPY RESOLUTION TEST CHART
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Table E-6. SIDAC post-processor results - 14 days sheltered, 7 days 2/3 sheltered.

URBAN

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.276	0.2	92.407	70.3	23.986	18.2	1.100	0.8	25.086	19.1	13.940	10.6	7
US	131.433	92.131	70.1	0.866	0.7	92.997	70.8	23.567	17.9	0.929	0.7	24.496	18.6	13.940	10.6	30
US	131.433	92.131	70.1	1.475	1.1	93.606	71.2	23.131	17.6	0.355	0.3	23.486	17.9	14.342	10.9	180

RURAL

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	0.927	1.1	8.420	10.1	12.219	14.7	7.636	9.2	19.854	23.9	54.879	66.0	7
US	83.153	7.493	9.0	2.598	3.1	10.091	12.1	11.840	14.2	6.045	7.3	17.885	21.5	55.177	66.4	30
US	83.153	7.493	9.0	4.368	5.3	11.861	14.3	11.431	13.7	1.821	2.2	13.252	15.9	58.040	69.8	180

6020/78W

Table E-7. SIDAC post-processor results - 21 days sheltered.

URBAN

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.221	0.2	92.352	70.3	24.024	18.3	0.900	0.7	24.924	19.0	14.157	10.8	7
US	131.433	92.131	70.1	0.710	0.5	92.841	70.6	23.677	18.0	0.773	0.6	24.450	18.6	14.142	10.8	30
US	131.433	92.131	70.1	1.213	0.9	93.344	71.0	23.316	17.7	0.313	0.2	23.629	18.0	14.459	11.0	180

RURAL

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	0.777	0.9	8.270	9.9	12.247	14.7	6.994	8.4	19.241	23.1	55.643	66.9	7
US	83.153	7.493	9.0	2.274	2.7	9.767	11.7	11.911	14.3	5.590	6.7	17.502	21.0	55.884	67.2	30
US	83.153	7.493	9.0	3.851	4.6	11.343	13.6	11.550	13.9	1.752	2.1	13.301	16.0	58.509	70.4	180

6020/78W

Table E-8. SIDAC post-processor results - attrition rate model - best case.

URBAN

CTRY	TOT POP	FATALITIES						INJURIES						RESIDUAL POP		ASSESS TIME
		PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL				
	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	0.962	0.7	93.093	70.8	23.500	17.9	1.833	1.4	25.333	19.3	13.006	9.9	7
US	131.433	92.131	70.1	2.059	1.6	94.190	71.7	22.717	17.3	1.541	1.2	24.259	18.5	12.984	9.9	30
US	131.433	92.131	70.1	3.238	2.5	95.369	72.6	21.872	16.6	0.645	0.5	22.516	17.1	13.548	10.3	180

RURAL

CTRY	TOT POP	FATALITIES						INJURIES						RESIDUAL POP		ASSESS TIME
		PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL				
	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	1.886	2.3	9.379	11.3	12.004	14.4	9.312	11.2	21.316	25.6	52.459	63.1	7
US	83.153	7.493	9.0	4.067	4.9	11.559	13.9	11.503	13.6	7.443	9.0	18.946	22.8	52.648	63.3	30
US	83.153	7.493	9.0	6.414	7.7	13.906	16.7	10.956	13.2	2.572	3.1	13.528	16.3	55.719	67.0	180

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Table E-9. SIDAC post-processor results - attrition rate model - worst case.

URBAN

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	131.433	92.131	70.1	1.503	1.1	93.634	71.2	23.117	17.6	2.415	1.8	25.532	19.4	12.267	9.3	7
US	131.433	92.131	70.1	3.024	2.3	95.155	72.4	22.031	16.8	1.961	1.5	23.991	18.3	12.287	9.3	30
US	131.433	92.131	70.1	4.676	3.6	96.807	73.7	20.845	15.9	0.735	0.6	21.580	16.4	13.046	9.9	180

RURAL

		FATALITIES						INJURIES								
	TOT POP	PROMPT		FALLOUT		TOTAL		PROMPT		FALLOUT		TOTAL		RESIDUAL POP		ASSESS TIME
CTRY	MIL	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	MIL	PCT	DAYS
US	83.153	7.493	9.0	2.671	3.2	10.164	12.2	11.831	14.2	10.799	13.0	22.630	27.2	50.360	60.6	7
US	83.153	7.493	9.0	5.302	6.4	12.794	15.4	11.220	13.5	8.517	10.2	19.738	23.7	50.621	60.9	30
US	83.153	7.493	9.0	8.158	9.8	15.650	18.8	10.551	12.7	2.799	3.4	13.349	16.1	54.154	65.1	180

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